LONG-TERM COHO SALMON & STEELHEAD TROUT MONITORING IN COASTAL MARIN COUNTY

POINT REYES NATIONAL SEASHORE ASSOCIATION

SUMMER 2004 MONITORING PROGRESS REPORT
PORE-NR/WR-05/04

CONTRACT PO330431

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ABSTRACT

The report summarizes coho salmon (*Oncorhynchus kisutch*) and steelhead (*O. mykiss*) monitoring efforts within Olema Creek, Pine Gulch Creek, and Redwood Creek in coastal Marin County, California during summer 2004. Index reach densities by habitat length and surface area are reported for Olema and Pine Gulch Creek, while basinwide juvenile coho population estimates are presented for all Olema, Pine Gulch, and Redwood Creek. We also present weight-length relationships and size histograms for coho and steelhead by watershed. Results from the 2004 summer monitoring season show the highest densities monitored in Olema Creek since surveys began in summer 1999. The basinwide population estimate for coho in the mainstem of Olema Creek (12.4 km reach) is 29,138 ± 1,591, based on calibrated densities of 78.12 coho per pool. The basinwide mainstem estimate for coho in Redwood Creek (7.4 km reach) is 7,121 ± 1,615, based on the calibrated density of 36.71 coho per pool. Our observed densities in Redwood Creek exceed any previously reported values. While we observed high numbers and densities of coho salmon in Olema and Redwood Creek, we observed very few coho individuals in Pine Gulch Creek, representing the lowest estimate (108 coho juveniles) since the return of coho to the watershed was documented in summer 2001.

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1.0 BACKGROUND AND OBJECTIVES

Ongoing monitoring of coho salmon by the National Park Service (NPS) within Olema Creek, Pine Gulch Creek, and Redwood Creek in coastal Marin County is supported through the Department of Fish and Game (DFG) Grant P0330431 and the NPS Inventory and Monitoring program. These monitoring efforts continue salmonid research initiated and conducted by the National Park Service since 1997. The primary focus of this monitoring grant is document federal and state endangered coho salmon (*Oncorhynchus kisutch*) population, distribution and trends within these watersheds. Established summer monitoring protocols are also effective at documenting information on federally threatened steelhead trout (*O. mykiss*) and fish community assemblage and condition within monitored stream reaches.

Program monitoring protocols are documented within the San Francisco Area Network Stream Aquatic Resource Monitoring Protocol (Ketcham et. al. 2005a). The associated program Summer Monitoring Standard Operating Protocol (SOP1) (Ketcham et. al. 2005b) documents methods used by the National Park Service (NPS) in salmonid monitoring within coastal Marin County since 1997.

This progress report documents results of index reach surveys and basinwide snorkel surveys for Pine Gulch Creek, Olema Creek, and Redwood Creek during summer 2004. These watersheds are located within the Lagunitas Creek and Bolinas Hydrologic Sub-Areas (HSA) of the Bodega and Marin Hydrologic Units. The Recovery Strategy for Coho Salmon (CDFG 2004) categorizes each of these HSAs as high priority restoration areas for coho salmon. The monitoring efforts conducted through this program contribute to our understanding of population condition and dynamics within the coastal Marin County Area (Figure 1.1).

In summer 2004, a total of 18 index sites in the Olema, Pine Gulch and Redwood Creek watersheds were sampled. In addition, staff conducted snorkel surveys on Olema Creek, Pine Gulch Creek, and Redwood Creek to develop basinwide estimates within these three watersheds. The results of index reach and snorkel survey information for Olema Creek, Pine Gulch Creek, and Redwood Creek are reported in this progress report. In spring 2004, staff iniated equiprobable general systematic sampling (GSS) using habitat surveys and electrofishing of systematically drawn pool units to estimate juvenile population and distribution on John West Fork and Quarry Gulch (tributary to Olema Creek) and Cheda Creek (tributary to Lagunitas Creek). The results from the GSS program were reported previously (Ketcham et.al. 2004a). The summer 2004 results presented within this progress report will be incorporated into watershed specific monitoring reports including winter adult, spring smolt, and summer monitoring activities. Results of index reach salmonid densities for Redwood Creek are not included in this report, but will be included in a subsequent report.

1.1 Index reach surveys

The index reach program was established in 1999 in an effort to standardize physical and biotic monitoring of temporal changes to the habitat. Annual monitoring allows staff to document change in habitat condition and size associated with winter runoff events and riparian structure. Evaluation of this information on a watershed by watershed basis will be valuable for predicting response to environmental and climactic conditions, adjustments in land management strategies, and for evaluation of success with regard to specific restoration activities. Additional index sites may be established as needed to assess future management and restoration actions or to sample areas not covered by existing sites.

Generally, the index sites are of two types: 1) controls to track natural variation and serve as a yardstick for measuring recovery of treatment sites; and 2) treatment sites to assess management actions. Index reaches are situated at somewhat regular intervals throughout the mainstem of each creek, and generally correspond to stream reaches with consideration of Rosgen channel type, land use patterns, other habitat characteristics, and professional judgement and knowledge of the watersheds. Where possible, index reaches coincide with water quality and aquatic macroinvertebrate monitoring sites. The composition of habitat types within the index reaches is intended to reflect the overall habitat conditions of the stream segments they represent, as determined by the habitat typing surveys that have been completed for each watershed.

Primary index stations have been monitored in Olema Creek since 1999 and Pine Gulch Creek since 2000. Index stations on Redwood Creek were established prior to National Park Service (NPS) monitoring by Dr. Jerry Smith of San Jose State University. Additional index reaches have been established on the mainstem of Redwood Creek to augment the long-term sites.

1.2 Snorkel surveys and basinwide estimates

Staff has combined the index reach sampling protocol with snorkel surveys and basinwide habitat surveys to allow for development of basinwide estimates (Dollof et al 1993) of coho salmon populations. Coho have been selected for this more intensive level of survey due to their overall numbers in the ESU, and their recent listing as endangered under CESA, and upgrade to endangered under the ESA.

In summer 2004, snorkel surveys and basinwide estimates were initiated in Redwood Creek. We also completed the second year of monitoring for Olema Creek and fourth year of monitoring on Pine Gulch Creek. Two major elements are required of the basinwide survey: habitat typing and snorkel counts. The combination of index reach monitoring and summer snorkel surveys requires approximately one month per watershed using the minimum field crew of two to three. The existing monitoring program has been able to recruit volunteers to assist with the index reach monitoring days, making this a feasible and reasonable monitoring program. Snorkel surveys are a learned skill that require patience and highly skilled observers.

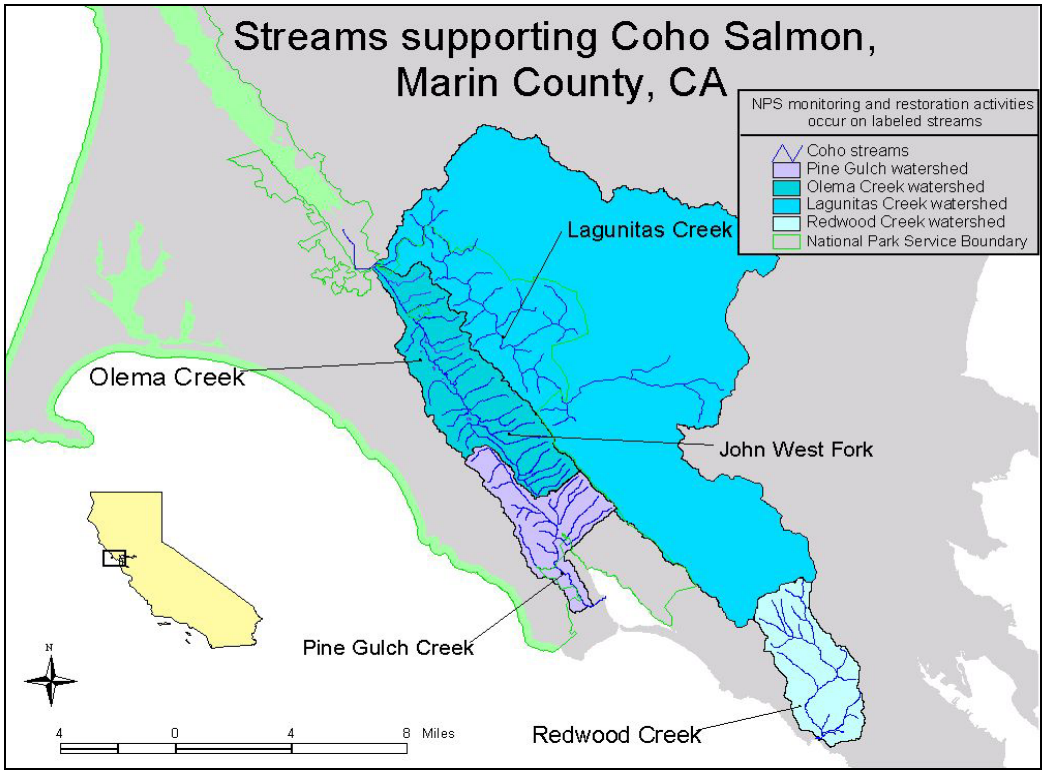

Figure 1.1 Streams supporting coho salmon in coastal Marin County.

2.0 METHODS

Complete index site histories and field methods are documented in SOP 1 of the San Francisco Area Network Stream Aquatic Resource Monitoring Protocol (Ketcham et. al. 2005b).

2.1 Index Reach Field Procedures

Index reaches have been established on Olema, Pine Gulch, Redwood Creek. Each index reach consists of a 30-100 meter reach, containing from three to ten contiguous habitat units, which are identified and sampled individually. Each habitat unit will be isolated with block nets and sampled separately using standard multiple pass depletion electrofishing methods (Bohlin et al 1989). Where appropriate, snorkel surveys or seine hauls may be used in conjunction with electrofishing.

Habitat measurements and assessments are made for the index reaches after fish sampling is completed. The length, average width and depth, substrate composition, and instream shelter complexity (Flosi et. al. 1998) are quantified in each habitat unit. Transects are set up across each habitat unit and depth and substrate type are recorded at points along the transects. Instream shelter complexity values are estimated for pool and flatwater units. Additional habitat parameters including bank erosion, riparian cover, and woody debris are then determined for the index site as a whole. The habitat portion of index reach monitoring must be completed the same day as fish sampling or very soon thereafter.

2.1.1 Electrofishing/handling

Captured fish are sedated using carbon dioxide (Alka Seltzer ™), identified to species and age class, measured, and weighed. To reduce impacts due to handling the fish, a subsample of 10 per pass, per species is measured and weighed. Some individuals are handled to collect fin clips or scale samples for age and/or genetic analysis. The remaining fish are then counted only. Fish are kept in aerated holding buckets before and after handling, and allowed to recover fully before being released.

An electrofishing log is kept of all settings, pertinent environmental conditions, fish response, and total catch for each unit. All electrofishing information is reported annually in Section 10 Reports to NOAA Fisheries. Water quality parameters are measured and recorded.

For habitat units sampled by multiple pass electrofishing, maximum likelihood model, *Microfish* (VanDeventer and Platts 1989) is used to calculate fish population estimates and confidence intervals by species/age class. Total catch is used as the population estimate for species with poor multiple pass depletions or no captures after the first pass, and in units sampled with a single pass.

2.2 Coho Juvenile Population Estimates

Basinwide surveys include three phases of sampling: habitat typing all units in a creek or survey reach, snorkeling a subsample (generally 20%) of the total units, and electrofishing a subsample of the snorkeled units. Divers then conduct snorkel counts on each of the previously determined pools. Target species are counted, and the presence of non-target fish and other aquatic species are documented, as well as cover, habitat complexity, and general survey conditions. A subsample of the snorkeled pools is then electrofished to calibrate the dive counts. Detailed instructions for basinwide surveys are given in Dollof et al (1993) and Collins (2003).

When conducted in conjunction with index reach surveys, calibration for the snorkel surveys is conducted using electrofishing results from pools within each index reach. In addition to the predetermined subsample of pools that are snorkeled, divers will also sample all index reach pool units that are within the basinwide survey area. Index reaches used as electrofishing calibration units for the basinwide survey should be snorkeled first to avoid biasing the dive counts. Electrofishing should be conducted as soon as possible after the snorkel counts, preferably the next day.

2.2.1 Habitat Typing

Starting at the bottom of the coho survey area and working upstream, staff numbered, classified, measured the length, and estimated the average width of each habitat unit. Units are classified to level III using the CDFG classification system (Flosi et al 1998) as pool (scour pool, backwater pool, plunge pool, or mid-channel pool), flatwater, or riffle. The width of each habitat unit was estimated visually. Every fifth pool unit was flagged for snorkeling and several measured widths were taken for the purpose of calibrating the estimated width. Index reach pools were also flagged for snorkeling.

2.2.2 Snorkel Counts

In 2004, as a result of low flow conditions and long recovery times within pool units, single pass dives were conducted on survey units using dive lights to search under vegetation, woody debris, and undercut banks. Only coho were counted but the presence of steelhead and non-salmonid fish was also noted. The number of divers in the water varied from 1 to 3, depending on the width and complexity of the unit. Strategies were used to divide the fish between the divers and filter them in such a way that the divers could be confident of their counts. This represents a more comprehensive effort than in years past, when only one diver was in the water at a time.

The pools within each index reach were electrofished the day after each snorkel survey. Calibration for the snorkel surveys is normally conducted using electrofishing results.

2.2.3 Data Management

Fish and habitat monitoring data is entered and stored in a Microsoft Access database managed through the NPS Inventory and Monitoring Program. Habitat survey, electrofishing, and snorkel survey data are then exported to Microsoft Excel for processing and analysis.

3.0 RESULTS

3.1 Index Reach Surveys

3.1.1 Olema Creek

Index reach monitoring was initiated at seven sites on Olema Creek in 1999. In 2000, Index Reach 8 was added to represent the intermittent portion of the upper mainstem. The stream kilometer (km) location of each index reach is presented in Table 3.1. In 2004, 6 of 8 index reaches on the mainstem of Olema Creek were sampled.

Table 3.1 Site location and number for Olema Creek index reach sites.

Index Site	Name/Location	Location Stream km
1*	Lower Stewarts Pasture/ Olema Flat	1.2
2	Vedanta	3.7
3	Cemetery Pond/ Upper Stewart's Pasture	4.9
4*	Truttman	6.3
5	Building 168	7.6
6	Horse Camp	9.4
7	5 Brooks	10.8
8	Lime Kilns/Upper Olema	13.0

*not surveyed in 2004

In spring 2004, we iniated equiprobable general systematic sampling (GSS) using habitat surveys and electrofishing of systematically drawn pool units to estimate juvenile population and distribution on John West Fork and Quarry Gulch. These data have been previously reported (Ketcham et al 2004a).

3.1.1.1 Historic index reach total salmonid catch

For the purpose of this report, the historic index reach total catch presents the annual fish numbers within index reaches monitored since 1999. Table 3.2 shows the variation in index reach totals between years and allows for anecdotal comparison of year classes. The summer monitoring information shows a dramatic increase in coho numbers in 2001 and 2002. These higher juvenile numbers correspond to similar patterns observed in adult spawner survey and spring outmigrant smolt trapping efforts conducted by the NPS.

The results presented in Table 3.2 are the real catch documented through electrofishing activities (Section 10 reporting) and are not used for any additional calculations in this report. Where multiple passes are used to sample a habitat unit, *Microfish* (maximum likelihood model) is used to calculate fish population estimates and confidence intervals by species/age class. Density results presented in Section 3.1.1.3 are determined based upon the habitat information described in Section 3.1.1.2 and the estimated populations determined from the multiple pass depletion method.

Table 3.2 Summary of total catch for each species by reach within Olema Creek mainstem index reach sample locations between 1999 and 2004; shows variation between years (e.g. higher coho #'s in 2001, 2002, and 2004) and distribution within watershed.

Year	Species	Index Reach								total
		1	2	3	4	5	6	7	8	
1999	CO	4	25	23	36	15	51	62	not sampled	216
	SH YOY	65	222	200	341	220	159	192		1,399
	SH 1+	17	19	27	39	46	31	17		196
2000	CO	1	64	21	140	34	76	23	0	359
	SH YOY	99	342	376	232	256	190	168	209	1,872
	SH 1+	24	19	11	24	22	12	19	6	137
2001	CO	39	23	73	257	213	205	241	156	1,207
	SH YOY	22	132	202	151	354	40	30	20	951
	SH 1+	15	26	17	37	34	29	26	7	191
2002	CO	3	114	123	not sampled	260	323	332	310	1,465
	SH YOY	26	102	439		267	118	139	203	1,294
	SH 1+	7	7	9		16	7	5	0	51
2003	CO	not sampled	22	5	60	210	152	202	72	723
	SH YOY		35	111	26	134	139	136	79	660
	SH 1+		8	7	11	27	21	9	9	92
2004	CO	not sampled	186	347	not sampled	295	239	175	164	1,406
	SH YOY		146	230		182	44	20	39	661
	SH 1+		6	10		26	24	10	8	84

3.1.1.2 Index Reach Habitat Information

In 2004, all monitored sites included the presence of coho and steelhead. Other aquatic species sampled at each index reach are documented. All index reach habitat information used to calculate density is presented in Table 3.3. Associated coho and steelhead density information is presented in Table 3.4, by habitat type, and Table 3.5 by index reach.

Index reach 1 was established to represent the lower three kilometers of the watershed where the stream meandered within an historically dredged channel. In 2002, Olema Creek permanently avulsed from this channel and is now flowing on its historic floodplain. The floodplain, operated as a pasture for the past thirty years, has no well established channel, and does not yet contain a forested riparian corridor. Since the avulsion, grazing has been removed and the riparian recovery is progressing rapidly. Because of these major hydrologic adjustments, Index 1 was not connected to mainstem flow, and no new station was established due to the dynamic channel conditions in this reach. In order to evaluate fish use within the downstream distributary floodplain habitat on Olema Creek, staff will incorporate seine surveys into the lower reaches as possible.

Index reach 2 was sampled on 7/20/04. It is located just upstream of the Vivekananda Bridge (Vedanta Retreat) near the town of Olema at stream km 3.7. This reach is representative of the deep incised but stable channel conditions occurring between the Bear Valley Road Bridge (km 2.6) and Olema Cemetery (km 4.3). Reach two consisted of 5 habitat units, including 2 pool units, 2 flatwater units and 1 riffle unit. The total length of the reach

was 103.5 m and the total surface area was 596.4 m^2. Pool units made up 47.4% of the total length and 37.6% of the total surface area. Also captured in Index 2 were ammocetes, roach, stickleback, sculpin, suckers and crayfish.

Index reach 3 was sampled on 7/22/04. It is located near stream km 4.9. This reach is fenced away from a heavily grazed field on the right bank and varies greatly in canopy cover. The riparian habitat is primarily hardwood including alder and bay trees. Reach three consisted of 4 habitat units, including 1 pool unit, 2 flatwater units and 1 riffle unit. The total length of the reach was 92.4 meters and the total surface area was 521.3 m^2. Pool units made up 22.4% of the total length and 25.9% of the total surface area. Also captured in Index 3 were ammocetes, roach, stickleback, sculpin, and crayfish.

Index reach 4 was not sampled in 2004. It is the most remote area and requires multiple electrofishers to conduct monitoring. Index reach 5 represents similar habitat.

Index reach 5 was sampled on 7/29/04. It is located near stream km 7.6 near Park Residence 168. A total of 5 habitat units were sampled, including 3 pool units and 2 riffle units. The total length of the reach was 106.7 m and the total surface area was 538.9 m^2. Pool units made up 81.7% of the total length and 86.1% of the total surface area. Also captured in Index 5 were ammocetes, roach, stickleback, sculpin, and crayfish.

Index reach 6 was sampled on 8/10/04. It is located near stream km 9.4 adjacent to the Stewart Horse Ranch pasture. This reach represents stable hardwood dominated habitat near active spawning areas. The fencing on the east side of the creek was recently moved back to 100 ft from the bank in order to allow for growth of a wider riparian zone (CDFG Grant P0030446). Reach 6 contained a total of 4 habitat units, including 3 pool units and 1 flatwater unit. The total length of the reach was 83.0 m and the total surface area was 339.4 m^2. Pool units made up 63.1% of the total length and 78.5% of the total surface area. Also captured in Index 6 were ammocetes, roach, stickleback, sculpin, suckers and crayfish.

Index reach 7 was sampled on 8/3/04. It is located near stream km 10.8, between the confluences of Giacomini Gulch and John West Fork within the Five Brooks area. The reach contained a total of 3 habitat units, including 2 pool units and 1 riffle unit. The total length of the reach was 51.9 m and the total surface area was 206.2 m^2. Pool units made up 84.6% of the total length and 90.3% of the total surface area. Also captured in Index 7 were ammocetes, stickleback, and sculpin.

Index reach 8 was sampled on 8/5/04. It is located near stream km 13.0 and represents the intermittent channel habitat conditions of upper Olema Creek. At the time of sampling, 3 isolated pools remained and 18.5 meters of the reach were dry. A total of 3 habitat units were sampled, including 3 pool units. The total length of the reach was 56.9 m with a surface area of 119.8 m^2. Pool units made up 67.5% of the total length and 100% of the total surface area. Also captured in Index 8 were sculpin.

Table 3.3 Summary of habitat composition; shows extent of area sampled and variation between reaches; Olema Creek, Summer 2004.

Index Reach	Habitat Type	# of Units	Length Sampled (m)	Length % of total	Surface area Sampled (m^2)	Surface area % of total
1	Pool			Not Sampled		
	Riffle					
	Flatwater					
	TOTAL					
2	Pool	2	49.1	47.4%	224.4	37.6%
	Riffle	1	9.9	9.6%	75.2	12.6%
	Flatwater	2	44.5	43.0%	296.9	49.8%
	TOTAL	5	103.5	100.0%	596.5	100.0%
3	Pool	1	20.7	22.4%	135.2	25.9%
	Riffle	1	11.1	12.0%	65.0	12.5%
	Flatwater	2	60.6	65.6%	321.1	61.6%
	TOTAL	4	92.4	100.0%	521.3	100.0%
4	Pool			Not Sampled		
	Riffle					
	Flatwater					
	TOTAL					
5	Pool	3	87.2	81.7%	463.8	86.1%
	Riffle	2	19.5	18.3%	75.1	13.9%
	Flatwater	0	0.0	0.0%	0.0	0.0%
	TOTAL	5	106.7	100.0%	538.9	100.0%
6	Pool	3	52.4	63.1%	266.6	78.5%
	Riffle	0	0.0	0.0%	0.0	0.0%
	Flatwater	1	30.6	36.9%	72.8	21.5%
	TOTAL	4	83.0	100.0%	339.4	100.0%
7	Pool	2	43.9	84.6%	186.2	90.3%
	Riffle	1	8.0	15.4%	20.0	9.7%
	Flatwater	0	0.0	0.0%	0.0	0.0%
	TOTAL	3	51.9	100.0%	206.2	100.0%
8	Pool	3	38.4	100.0%	119.8	100.0%
	Riffle	0	0.0	0.0%	0.0	0.0%
	Flatwater	0	0.0	0.0%	0.0	0.0%
	TOTAL	3	38.4	100.0%	119.8	100.0%
Total	**Pool**	**14**	**291.7**	**61.3%**	**1396.0**	**60.1%**
	Riffle	**5**	**48.5**	**10.2%**	**235.3**	**10.1%**
	Flatwater	**5**	**135.7**	**28.5%**	**690.8**	**29.8%**
	TOTAL	**24**	**475.9**	**100.0%**	**2322.1**	**100.0%**

3.1.1.3 Salmonid density by habitat type

The results of our monitoring efforts show distinct differences in salmonid numbers and densities based on habitat type (Table 3.4). The results show distinct use of pools by coho with fish densities of 4.26 fish/meter and 0.89 fish/meter^2 occurring in this habitat. Steelhead young of year preferred flatwater habitat with densities of 2.39 fish/meter compared to 1.38 fish/meter observed in pool habitat. This is reasonable considering the difference between pool and flatwater is depth. Steelhead are less discriminating about depth as a feature of habitat choice, and therefore, tend to occur in most stream habitat, even at very shallow depths.

Table 3.4 Summary of population and density estimates for each species by habitat unit on Olema Creek, Summer 2004; illustrates variation in distribution between habitat types.

Habitat Type	Species (age)	Population Estimate		Density			
		# of Fish	95% CI	Fish/m	95% CI	Fish/m^2	95% CI
Pools (n=14)	CO	1243	±206	4.26	±0.71	0.89	±0.15
	SH YOY	402	±97	1.38	±0.33	0.29	±0.07
	SH (1+)	76	±45	0.26	±0.16	0.05	±0.03
Riffles (n=5)	CO	*Not Surveyed					
	SH YOY						
	SH (1+)						
Flatwater (n=5)	CO	399	±59	2.94	±0.43	0.58	±0.08
	SH YOY	325	±41	2.39	±0.30	0.47	±0.06
	SH (1+)	13	±29	0.10	±0.18	0.02	±0.04
	Average Density		CO	**3.84**	**±0.62**	**0.79**	**±0.13**
			SH (0+)	**1.70**	**±0.32**	**0.35**	**±0.07**
			SH (1+)	**0.21**	**±0.16**	**0.04**	**±0.03**

* Riffles were not surveyed in 2004 due to low flow conditions and potential to injure fish as a result of electrofishing and netting activities.

Densities reported in Table 3.5 are determined from all habitat units surveyed within each index reach. Coho densities recorded in 2004 were highest in index reaches 3 (5.09 fish/m), 7 (5.06 fish/m), and 8 (4.70 fish/m). The densities reported in 2004 are much higher than those observed in 2003 where index 5 (2.02 fish/m), 6 (2.16 fish/m), and 7 (3.24 fish/m) represented the highest coho densities.

Table 3.5 Summary of population and density estimates for each species by reach on Olema Creek, Summer 2004; illustrates variation between reaches and provides a general idea of distribution within watershed.

Index Reach	Species (age)	Population Estimate		Density			
		# of Fish	95% CI	Fish/m	95% CI	Fish/m²	95% CI
1	CO	Not Surveyed					
	SH YOY						
	SH (1+)						
2	CO	194	±25	2.07	±0.27	0.34	±0.07
	SH YOY	166	±34	1.77	±0.36	0.32	±0.06
	SH (1+)	6	±29	0.06	±0.31	0.01	±0.06
3	CO	414	±72	5.09	±0.89	0.91	±0.16
	SH YOY	255	±41	3.14	±0.50	0.56	±0.09
	SH (1+)	10	±12	0.12	±0.15	0.02	±0.03
4	CO	Not Surveyed					
	SH YOY						
	SH (1+)						
5	CO	310	±36	3.56	±0.41	0.67	±0.08
	SH YOY	200	±33	2.29	±0.38	0.43	±0.07
	SH (1+)	27	±11	0.31	±0.12	0.06	±0.02
6	CO	279	±66	3.36	±0.79	0.82	±0.19
	SH YOY	44	±12	0.53	±0.15	0.13	±0.09
	SH (1+)	24	±5	0.46	±0.09	0.09	±0.02
7	CO	222	±60	5.06	±1.37	1.19	±0.32
	SH YOY	20	±4	0.46	±0.08	0.11	±0.02
	SH (1+)	10	±3	0.23	±0.08	0.05	±0.02
8	CO	232	±8	4.70	±0.17	1.46	±0.05
	SH YOY	54	±17	1.09	±0.35	0.36	±0.11
	SH (1+)	12	±4	0.24	±0.09	0.08	±0.03
	Average Densities		CO	**3.84**	**±0.62**	**0.79**	**±0.13**
			SH (0+)	**1.70**	**±0.32**	**0.35**	**±0.07**
			SH (1+)	**0.21**	**±0.16**	**0.04**	**±0.03**

3.1.1.4 Summer fish measurement information

As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. Histograms are presented for coho (Figure 3.1) and steelhead (Figure 3.3). Weight-length relationships are shown for coho (Figures 3.2) and steelhead (Figure 3.4). Future analysis will include fish condition as determined by Fulton's condition factor.

Within the Olema Creek sample, 175 coho salmon (12% of the total index reach catch) and 218 steelhead trout (29% of the total index reach catch) were weighed and measured. In the past, nearly all fish were weighed and measured. The subsamples represent a large reduction in handling impacts. The size range for coho was observed to be 45 to 125 millimeters, while the size range for steelhead trout was 30 to 205 millimeters. We speculate that the coho over

90 mm in size represent different year classes. Summer 2004 was the first year that coho in excess of 99 mm have been observed as part of the Olema Creek summer monitoring efforts (Ketcham et. al. 2004).

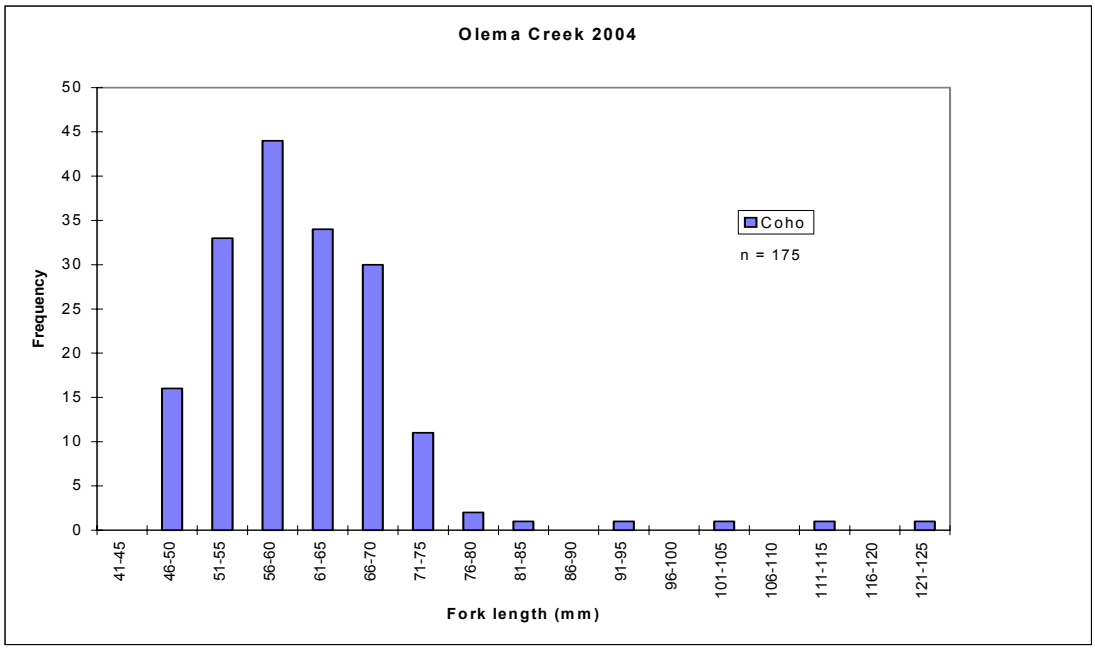

Figure 3.1 Coho histogram for fish measured in the six Olema Creek index reaches, 2004. Fork length is represented in 5 millimeter bins.

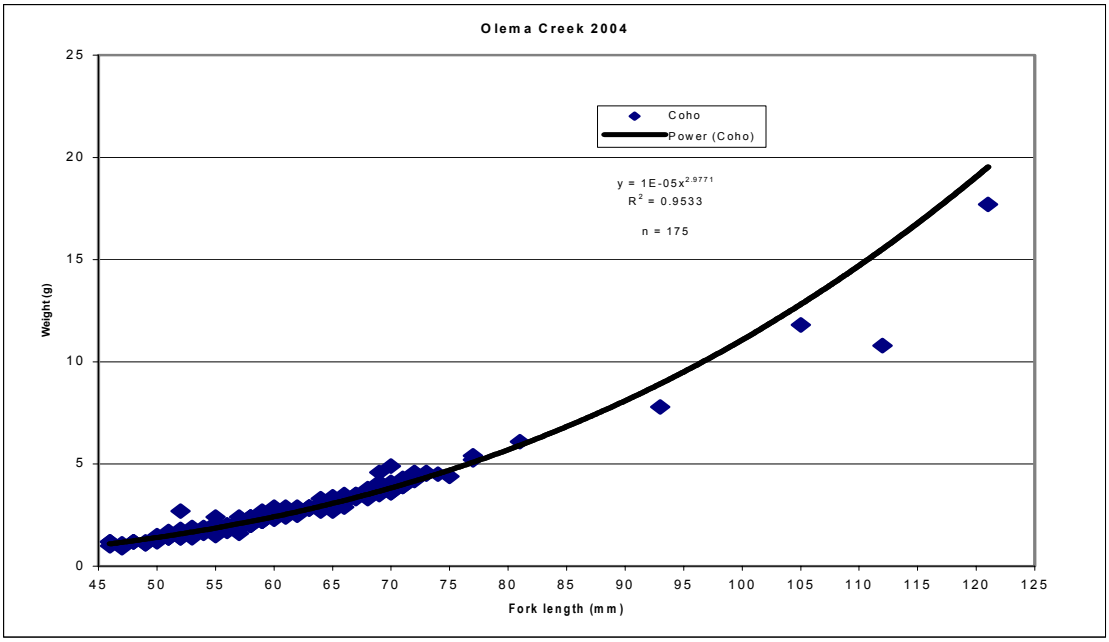

Figure 3.2 Coho weight-length relationships for fish measured in the six Olema Creek index reaches, 2004.

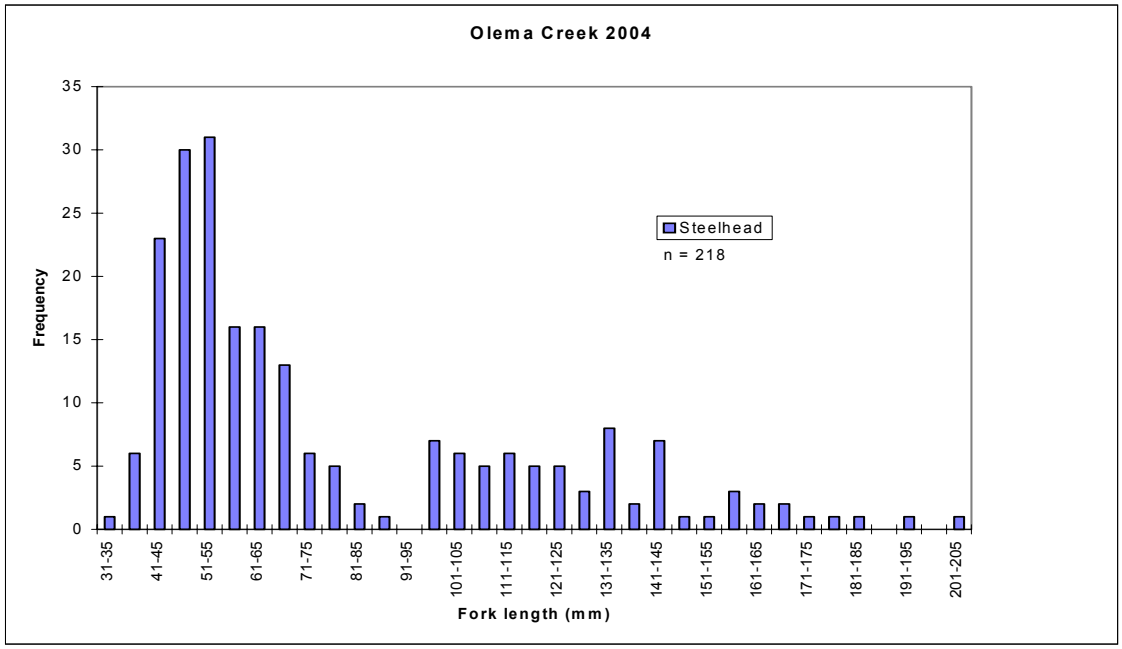

Figure 3.3 Steelhead histogram for fish measured in the six Olema Creek index reaches, 2004. Fork length is represented in 5 millimeter bins. Multiple peaks represent multiple year classes of O. Mykiss.

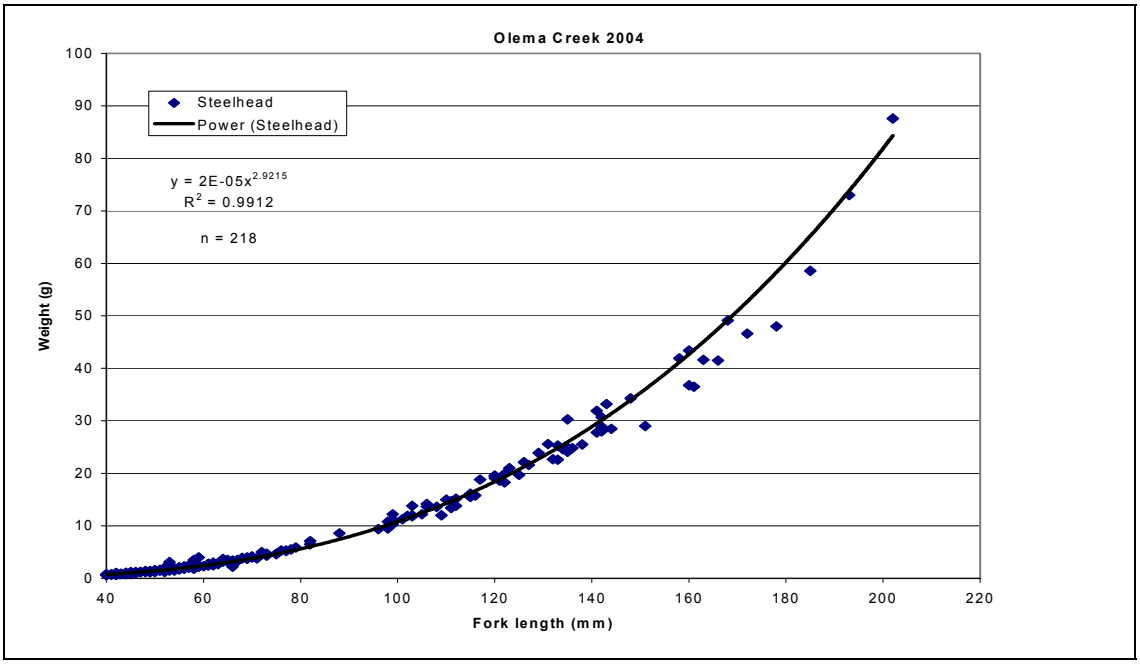

Figure 3.4 Steelhead weight-length relationships for fish measured in the six Olema Creek index reaches, 2004.

3.1.2 Pine Gulch Creek

Index reach monitoring was initiated at eight sites on Pine Gulch Creek in 2000. The stream kilometer (km) location of each index reach is presented in Appendix A and Table 3.6. In 2004, 7 of 8 index reaches on the mainstem of Pine Gulch Creek were sampled. Index reach electrofishing surveys were conducted on Pine Gulch Creek from July 15 through September 3, 2004. In 2004, coho salmon were present in index reaches 1b, 1c, 2, and 3. In 2004, index reach 4 area was not snorkeled due to water quality conditions associated with direct and recent access of cattle to the survey area.

Table 3.6 Site location and number for Pine Gulch Creek index reach sites.

Index Site	Name/Location	Location Stream km
1a	Marin County Open Space District (MCOSD)	0.2
1b	Murch	0.4
1c	Weber	0.7
2	Paradise Valley	2.7
3	Pine Gulch Gorge	3.9
4*	BCPUD pasture	5.1
5	Lower Texeira	6.8
6	Upper Texeira	7.8

*not sampled in 2004.

3.1.2.1 Historic index reach total salmonid catch

For the purpose of this report, the historic index reach total catch is presented to represent the annual variation in fish numbers within index reaches monitored since 2000. Table 3.7 shows the variation in index reach totals between years and will allow for anecdotal comparison of year classes in future years. Very few coho were observed within the watershed during all survey activities, including five coho during electrofishing and 21 coho during snorkel surveys.

Table 3.7 Summary of total catch for each species by reach within Pine Gulch Creek mainstem index reach sample locations between 2000 and 2004 (NPS 2002a, 2002b, 2003).

Year	Species	Index Reach								total
		1a	1b	1c	2	3	4	5	6	
2000	CO	0	0	0	0	0	0	0	0	0
	SH YOY	16	71	74	75	76	84	51	30	477
	SH 1+	3	16	28	21	14	21	19	6	128
2001	CO	0	1	0	4	15	0	31	0	51
	SH YOY	4	55	64	55	47	57	27	15	324
	SH 1+	1	11	22	46	20	15	32	23	170
2002	CO	0	1	2	11	16	34*	24	6	94
	SH YOY	11	73	51	110	244	-	90	86	665
	SH 1+	6	22	29	14	18	-	25	18	132
2003	CO	0	0	0	10	12	not sampled	8	1	31
	SH YOY	24	87	72	115	185		64	20	567
	SH 1+	13	17	22	24	15		20	13	124
2004	CO	0	1	1	2	1	not sampled	0	0	5
	SH YOY	10	80	55	99	144		80	46	514
	SH 1+	6	18	33	12	16		16	4	105

* snorkel survey result

3.1.2.2 Index Reach Habitat Information

In 2004, all index reaches included the presence of steelhead, with coho documented in reaches 1b, 1c, 2, and 3. Other aquatic species sampled at each index reach are documented. All index reach habitat information used to calculate density is presented in Table 3.8. Associated coho and steelhead density information is presented in Table 3.9, by habitat type, and Table 3.10 by index reach.

Pine Gulch Creek Index 1a, through 1c were established to represent the lower reaches of the watershed where the stream flows through organic agricultural cropland. The NPS and other agencies are working with these landowners to enhance operations to protect instream flow for the benefit of coho salmon and steelhead trout. Sampling in these private lands is done with the cooperation of the landowners.

Index Reach 1a was sampled on 9/3/04. It is located in the lowest 200 meters of freshwater habitat within Marin County Open Space District Land. Three habitat units were sampled in this reach, including 1 pool unit, 1 flatwater unit and 1 riffle unit. The total length of the sampled reach was 20.3 m and the total surface area was 42.2 m^2. Pool units made up 56.7% of the total length and 66.5% of the total surface area. Also captured in Index 1a were ammocetes, and sculpin.

Index reach 1b was sampled on 7/15/04. It is located just upstream of the NPS stream gage on the Murch property. Reach 1b consisted of 3 habitat units, including 1 pool unit and 2 flatwater units. The total length of the reach was 69.8 m and the total surface area was 182.8 m^2. Pool units made up 17.5% of the total length and 18% of the total surface area. Also captured in Index 1b were ammocetes, and sculpin.

Index reach 1c was sampled on 8/17/04. It is located 100 m upstream of the Olema-Bolinas Road Bridge on the Star Route Farms property. Reach 1c consisted of 5 habitat units, including 3 pool units and 2 riffles. The total length of the reach was 58.7 m and the total surface area was 167.8 m^2. Pool units made up 68.5% of the total length and 87.8% of the total surface area. Also captured in Index 1c were ammocetes, and sculpin.

Index reach 2 was sampled on 8/19/04. It is located near stream km 2.8. This reach is located in Paradise Valley on land recently purchased from the Martinelli Family Trust. The new landowner is supportive of ongoing monitoring activities. The riparian habitat is primarily hardwood including alder and bay trees. Reach 2 consisted of 5 habitat units, including 3 pool units, 1 flatwater unit and 1 riffle unit. The total length of the surveyed reach was 57.9 meters and the total surface area was 210.1 m^2. Pool units made up 55.4% of the total length and 65.5% of the total surface area. Also captured in Index 2 were ammocetes and sculpin.

Index reach 3 was sampled on 8/25/04. It is located near stream km 3.9, at the lower end of the gorge. This is a steep canyon area with dense riparian cover, and deep stable bedrock controlled habitat. Reach 3 consisted of 4 habitat units, including 2 pool units and 2 flatwater units. The total length of the surveyed reach was 62.7 m and the total surface area sampled was 194.1 m^2. Pool units made up 58.2% of the total length and 64.9% of the total surface area. Also captured in Index 3 were ammocetes, stickleback, sculpin, and crayfish.

Index 4 of Pine Gulch has not been possible to electrofish since 2001 due to issues with site access through private property. In 2001 and 2002, snorkel surveys were conducted in this reach as part of the population estimate surveys. In 2003 and 2004, this area was not snorkeled due to water quality conditions associated with direct and recent access of cattle to the survey area within the creek.

Index Reach 5 was sampled 8/27/04. It is located near stream km 6.8 within the Texiera Flats area. A total of 5 habitat units were sampled, including 2 pool units, 1 flatwater unit and 2 riffles. The total length of the reach was 59.0 m and the total surface area was 218.6 m^2. Pool units made up 58.8% of the total length and 64.3% of the total surface area. Also captured in Index 5 were ammocetes and sculpin.

Index reach 6 was sampled on 9/1/04. It is located near stream km 7.8 upstream of the Texiera House. Reach 6 contained a total of 6 habitat units, including 3 pool units, 2 flatwater units, and 1 riffle unit. The total length of the reach was 53.6 m and the total surface area was 129.4 m^2. Pool units made up 71.5% of the total length and 80.0% of the total surface area. Also captured in Index 6 were ammocetes, and sculpin.

Table 3.8 Summary of habitat composition; shows extent of area sampled and variation between reaches; Pine Gulch Creek Summer 2004.

Index Reach	Habitat Type	# of Units	Length Sampled (m)	Length % of total	Surface area Sampled (m^2)	Surface area % of total
	Pool	1	11.5	56.7%	28.1	66.5%
1a	Riffle	1	3.4	16.7%	3.2	7.5%
	Flatwater	1	5.4	26.6%	11.0	26.0%
	TOTAL	3	20.3	100.0%	42.3	100.0%
	Pool	1	12.2	17.5%	32.9	18.0%
1b	Riffle	0	0.0	0.0%	0.0	0.0%
	Flatwater	2	57.6	82.5%	149.9	82.0%
	TOTAL	3	69.8	100.0%	182.8	100.0%
	Pool	3	40.2	68.5%	147.4	87.8%
1c	Riffle	2	18.5	31.5%	20.4	12.2%
	Flatwater	0	0.0	0.0%	0.0	0.0%
	TOTAL	5	58.7	100.0%	167.8	100.0%
	Pool	3	32.1	55.5%	137.7	65.5%
2	Riffle	1	11.3	19.5%	24.5	11.7%
	Flatwater	1	14.5	25.0%	48.0	22.8%
	TOTAL	5	57.9	100.0%	210.2	100.0%
	Pool	1	36.5	58.2%	125.9	64.9%
3	Riffle	0	0.0	0.0%	0.0	0.0%
	Flatwater	2	26.2	41.8%	68.2	35.1%
	TOTAL	3	62.7	100.0%	194.1	100.0%
	Pool					
4	Riffle			Not sampled		
	Flatwater					
	TOTAL					
	Pool	2	34.7	58.8%	140.5	64.3%
5	Riffle	2	13.2	22.4%	47.8	21.9%
	Flatwater	1	11.1	18.8%	30.2	13.8%
	TOTAL	5	59.0	100.0%	218.5	100.0%
	Pool	3	38.3	71.5%	103.5	80.0%
6	Riffle	1	3.6	6.7%	5.6	4.3%
	Flatwater	2	11.7	21.8%	20.3	15.7%
	TOTAL	6	53.6	100.0%	129.4	100.0%
	Pool	**14**	**205.5**	**53.8%**	**716.0**	**62.5%**
Total	**Riffle**	**7**	**50.0**	**13.1%**	**101.5**	**8.9%**
	Flatwater	**9**	**126.5**	**33.1%**	**327.6**	**28.6%**
	TOTAL	**30**	**382.0**	**100.0%**	**1145.1**	**100.0%**

3.1.2.3 Salmonid density by habitat type

Pools are typically the best habitat for both coho salmon and steelhead trout, and consistently support higher densities than flatwater and riffle units. Table 3.9 shows the breakout of habitat units and fish densities. Only 5

coho were observed within the eight Pine Gulch Creek index reaches in 2004. All observations were in pool habitat and the number is so low, that no significance can be drawn from this sample size. As observed in Olema Creek, steelhead occur in all habitat types, though in varying densities. Steelhead densities observed in 2004 were slightly lower than those observed in 2003.

Table 3.9 Summary of population and density estimates for each species by habitat unit on Pine Gulch Creek, Summer 2004; illustrates variation in distribution between habitat types.

Habitat Type	Species (age)	Population Estimate		Density			
		# of Fish	95% CI	Fish/m	95% CI	Fish/m²	95% CI
Pools (n=14)	CO	5**	**	0.02**	**	0.007**	**
	SH YOY	363	±46	1.77	±0.23	0.51	±0.06
	SH (1+)	93	±28	0.45	±0.14	0.13	±0.04
Riffles (n=7)	CO	*Not Surveyed					
	SH YOY						
	SH (1+)						
Flatwater (n=9)	CO	0**	**	**	**	**	**
	SH YOY	154	±36	1.22	±0.28	0.47	±0.11
	SH (1+)	12	±23	0.09	±0.18	0.04	±0.07
	Average Density		CO	**0.02**		**0.005**	
			SH (0+)	**1.56**	**±0.25**	**0.50**	**±0.08**
			SH (1+)	**0.32**	**±0.15**	**0.10**	**±0.05**

* Riffles were not surveyed in 2004 due to low flow conditions.

** Only 5 CO were recovered during index surveys. CO numbers did not support a reliable population estimate.

Table 3.10 Summary of population and density estimates for each species by reach on Pine Gulch Creek, Summer 2004; illustrates variation between reaches and provides a general idea of distribution within watershed.

Index Reach	Species (age)	Population Estimate		Density			
		# of Fish	95% CI	Fish/m	95% CI	Fish/m²	95% CI
	CO	0*	*	*	*	*	*
1a	SH YOY	10	±3	0.59	±0.16	0.26	±0.07
	SH (1+)	6	±1	0.36	±0.07	0.15	±0.03
	CO	1*	*	0.01*	*	0.005*	*
1b	SH YOY	80	±5	1.15	±0.08	0.44	±0.03
	SH (1+)	18	±5	0.26	±0.07	0.1	±0.03
	CO	1*	*	0.02*	*	0.006*	*
1c	SH YOY	56	±8	1.39	±0.21	0.38	±0.06
	SH (1+)	33	±5	0.82	±0.12	0.22	±0.03
	CO	2*	*	0.03*	*	0.01*	*
2	SH YOY	102	±11	2.19	±0.23	0.55	±0.06
	SH (1+)	12	±10	0.26	±0.22	0.06	±0.06
	CO	1*	*	0.02*	*	0.005*	*
3	SH YOY	147	±11	2.34	±0.18	0.76	±0.06
	SH (1+)	16	±20	0.26	±0.33	0.08	±0.11
	CO						
4	SH YOY	Not Surveyed					
	SH (1+)						
	CO	0*	*	*	*	*	*
5	SH YOY	86	±17	1.88	±0.37	0.50	±0.10
	SH (1+)	16	±3	0.35	±0.06	0.09	±0.02
	CO	0*	*	*	*	*	*
6	SH YOY	46	±31	0.92	±0.06	0.37	±0.25
	SH (1+)	4	±6	0.08	±0.13	0.03	±0.05
	Average Densities		CO	**0.02**		**0.005**	
			SH (0+)	**1.56**	**±0.25**	**0.50**	**±0.08**
			SH (1+)	**0.32**	**±0.15**	**0.10**	**±0.05**

* Only 5 CO were recovered during index surveys. CO numbers did not support a reliable population estimate.

3.1.2.4. Summer fish measurement information

As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. Histograms are presented for coho (Figure 3.5) and steelhead (Figure 3.7). Weight-length relationships are shown for coho (Figures 3.6 and steelhead (Figure 3.8). Future analysis will include fish condition as determined by Fulton's condition factor.

Within the Pine Gulch Creek sample, 5 coho salmon (100% of the total index reach catch) and 295 steelhead trout (48% of the total index reach catch) were weighed and measured. The size range for coho was observed to be 65 to 115 millimeters, while the size range for steelhead trout was 35 to 215 millimeters. Based on our observation through the years, coho documented at this time of year, exceeding 90mm are likely year old fish, which would

smolt as a 2 year old. One of the five coho individuals observed during the monitoring was likely a hold over observed in index reach 3.

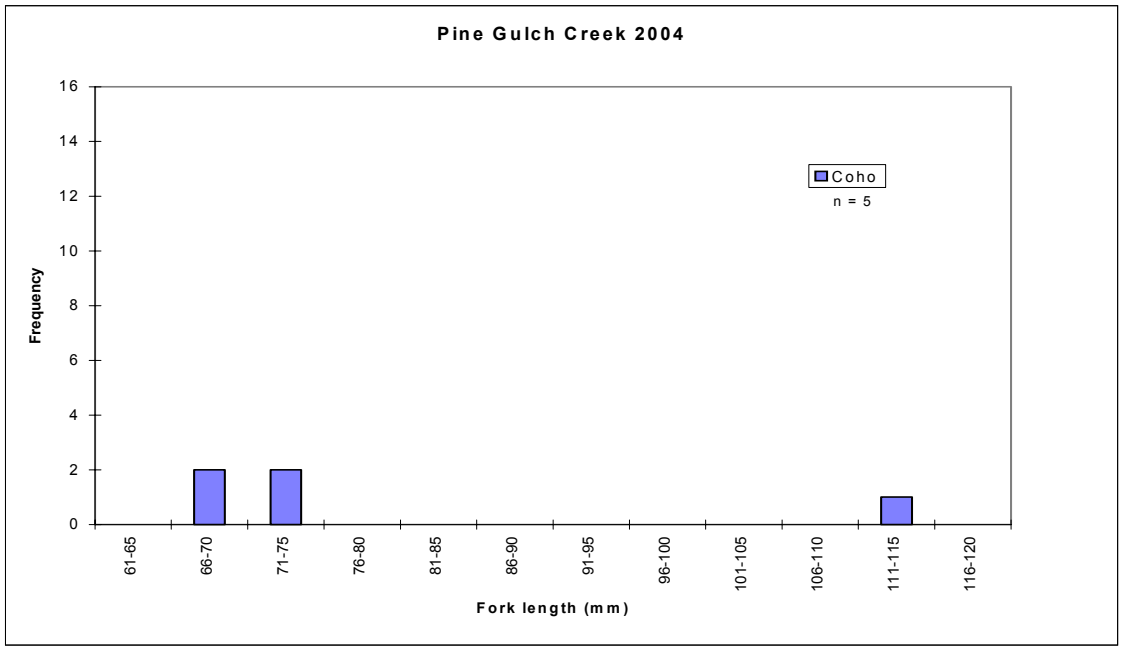

Figure 3.5 Coho histogram for fish measured in the seven Pine Gulch Creek index reaches, 2004. Fork length is represented in 5 millimeter bins.

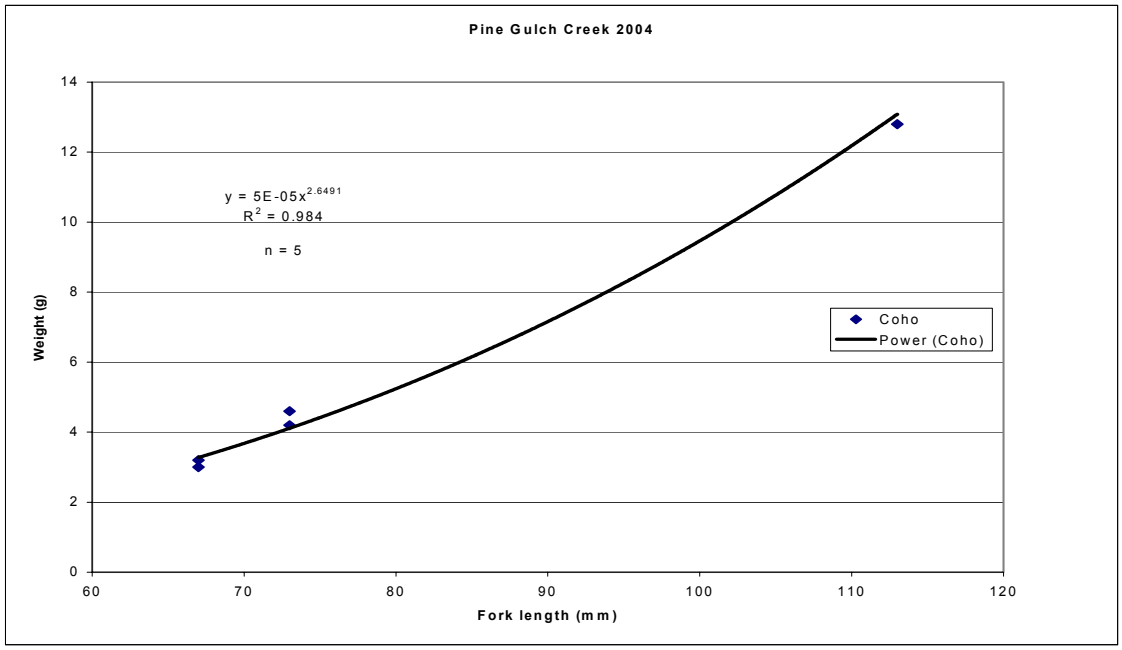

Figure 3.6 Coho weight-length relationships for fish measured in the seven Pine Gulch Creek index reaches, 2004.

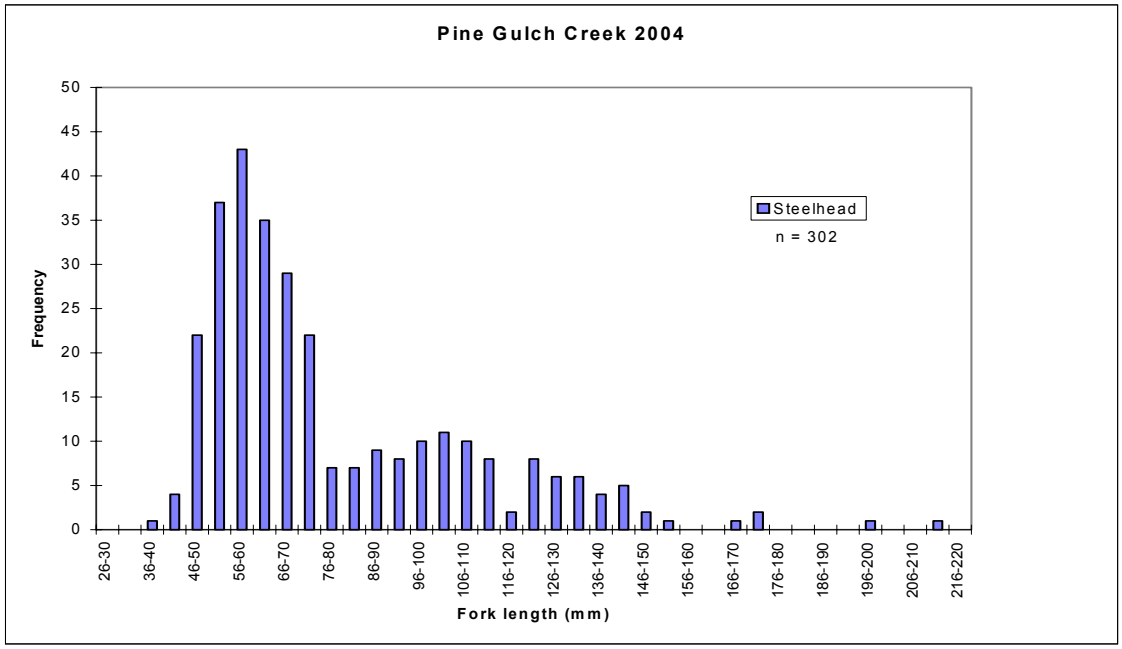

Figure 3.7 Steelhead histogram for fish measured in the seven Pine Gulch Creek index reaches, 2004. Fork length is represented in 5 millimeter bins. Multiple peaks represent multiple year classes of O. Mykiss.

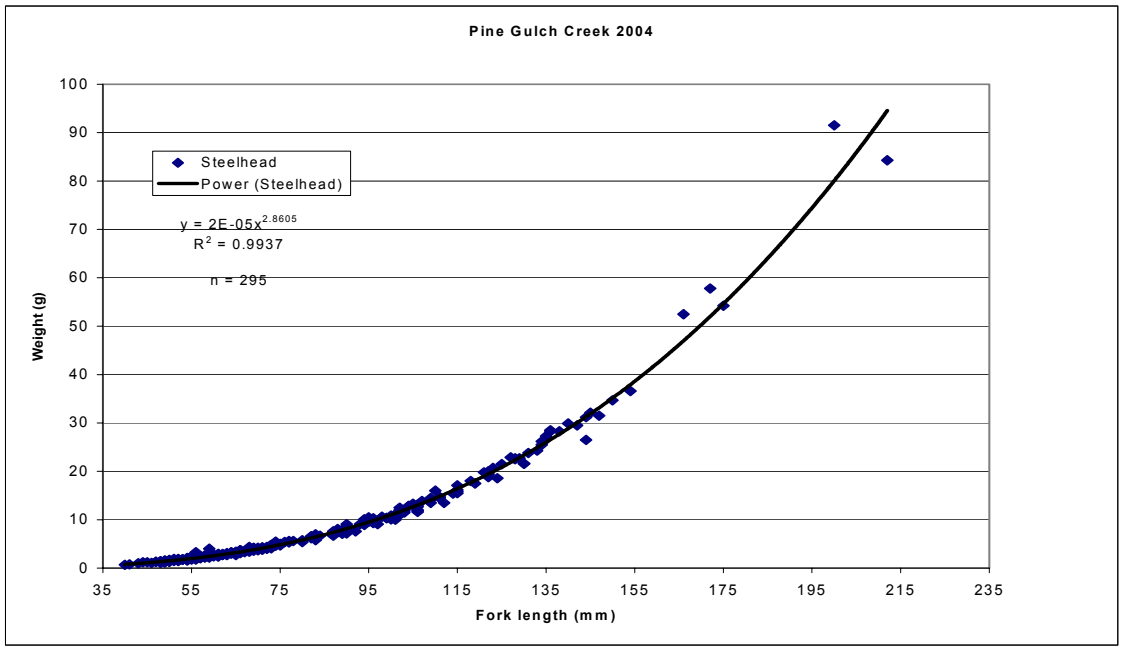

Figure 3.8 Steelhead weight-length relationships for fish measured in the seven Pine Gulch Creek index reaches, 2004.

3.1.3 Redwood Creek

Dr. Jerry Smith (SJSU) established 5 index reaches on Redwood Creek in 1992; monitoring of these sites will be shared between Dr. Smith and NPS. Two additional index sites, MUWO boardwalk and Banducci, were added by GOGA in 2001 to represent habitat units not being covered by Dr. Jerry Smith. The stream kilometer (km) location of each index reach is presented in Table 3.11. In 2004, 5 of 7 index reaches on the mainstem of Redwood Creek were sampled.

Table 3.11 Site location and number for Redwood Creek index reach sites.

Index Site	Name/Location	Location Stream km
1	MUWO boardwalk	6.3
2	MUWO restroom	5.2
3	Miwok Trail Crossing	3.8
4	Kent Creek	2.9
5	Frank Valley Road Bridge	1.9
6	Banducci	0.8
7	Pacific Way Bridge	0.1

3.1.3.1 Historic index reach total salmonid catch

Table 3.12 presents summer 2004 monitoring results from NPS monitoring efforts. A summary of previous monitoring years is being compiled as part of the Redwood Creek Watershed Report to be completed in fall 2005.

Table 3.12 Summary of total catch (Not including Dr. Jerry Smith information) for each species by reach within Redwood Creek mainstem index reach sample locations 2004.

Year	Species	Index Reach							total
		1	2	3	4	5	6	7	
2004	CO	Not sampled	42	95	74	159	71	not sampled	441
	SH YOY		6	22	19	24	4		75
	SH 1+		19	8	17	15	13		72

3.1.3.2 Index Reach Habitat Information

In 2004, all index reaches included the presence of coho and steelhead. Other aquatic species sampled at each index reach are documented. All index reach habitat information used to calculate density is presented in Table 3.13. Associated coho and steelhead density information is presented in Table 3.14, by habitat type, and Table 3.15 by index reach.

Index Reach 1 was not sampled. October rains changed conditions and made sampling not representative.

Index reach 2 was sampled on 10/22/04. It is located behind the Muir Woods National Monument's restrooms. Reach 2 consisted of 4 habitat units, including 2 pool units, 1 flatwater unit and 1 riffle. The total length of the reach was 49.4 m and the total surface area was 231.0 m^2. Pool units made up 55.3% of the total length and 69.8% of the total surface area. Also captured in Index 2 were sculpin.

Index reach 3 was sampled on 10/14/04. It is located near stream km 3.8 at the Miwok Trail footbridge crossing. Reach 3 consisted of 4 habitat units, including 3 pool units and 1 riffle. The total length of the reach was 55.7 m and the total surface area was 154.9 m^2. Pool units made up 86.9% of the total length and 96.1% of the total surface area. Also captured in Index 3 were sculpin and crayfish.

Index reach 4 was sampled on 10/6/04. It is located near stream km 2.9 at the Kent Creek confluence on Redwood Creek. Reach 4 consisted of 6 habitat units, including 3 pool units, 2 flatwater units and 1 riffle unit. The total length of the surveyed reach was 79.2 meters and the total surface area was 206.8 m^2. Pool units made up 69.8% of the total length and 79.2% of the total surface area. Also captured in Index 4 were sculpin and crayfish.

Index reach 5 was sampled on 9/30/04. It is located near stream km 1.9 upstream of the Frank Valley Road bridge. Reach 5 consisted of 5 habitat units, including 3 pool units, 1 flatwater unit, and 1 riffle. The total length of the surveyed reach was 106.6 m and the total surface area sampled was 440.7 m^2. Pool units made up 75.8% of the total length and 85.5% of the total surface area. Also captured in Index 5 were sculpin, and crayfish.

Index reach 6 was sampled on 9/30/04. It is located near stream km 0.8 at the Banducci restoration site. Reach 6 contained a total of 9 habitat units, including 2 pool units, 3 flatwater units, and 4 dry units. The total length of the reach was 83.3 m and the total surface area was 114.9 m^2. Pool units made up 30.4% of the total length and 69.4% of the total surface area. Also captured in Index 6 were sculpin and crayfish.

Index Reach 7 was not sampled. In September 2004, Reach 7, downstream of the Pacific Way Bridge on Redwood Creek, was dry and therefore not sampled.

Table 3.13 Summary of habitat composition; shows extent of area sampled and variation between reaches; Redwood Creek Summer 2004.

Index Reach	Habitat Type	# of Units	Length Sampled (m)	Length % of total	Surface area Sampled (m^2)	Surface area % of total
1	Pool			Not sampled		
	Riffle					
	Flatwater					
	TOTAL					
2	Pool	2	27.3	55.3%	161.2	69.8%
	Riffle	1	6.2	12.6%	26.4	11.4%
	Flatwater	1	15.9	32.2%	43.4	18.8%
	TOTAL	4	49.4	100.0%	231.0	100.0%
3	Pool	3	48.4	86.9%	148.9	96.1%
	Riffle	1	7.3	13.1%	6.0	3.9%
	Flatwater	0	0.0	0.0%	0.0	0.0%
	TOTAL	4	55.7	100.0%	154.9	100.0%
4	Pool	3	55.3	69.8%	163.8	79.2%
	Riffle	1	3.1	3.9%	6.0	2.9%
	Flatwater	2	20.8	26.3%	37.1	17.9%
	TOTAL	6	79.2	100.0%	206.9	100.0%
5	Pool	3	80.8	75.8%	376.7	85.5%
	Riffle	1	4.9	4.6%	4.4	1.0%
	Flatwater	1	20.9	19.6%	59.6	13.5%
	TOTAL	5	106.6	100.0%	440.7	100.0%
6	Pool	2	25.3	30.4%	79.8	69.4%
	Riffle	0	0.0	0.0%	0.0	0.0%
	Flatwater	3	13.9	16.7%	35.2	30.6%
	Dry	4	44.1	52.9%	0.0	0.0%
	TOTAL	9	83.3	100.0%	115.0	100.0%
7	Pool			Not sampled		
	Riffle					
	Flatwater					
	TOTAL					
Total	**Pool**	**13**	**237.1**	**63.4%**	**930.4**	**81.0%**
	Riffle	**4**	**21.5**	**5.7%**	**42.8**	**3.7%**
	Flatwater	**7**	**71.5**	**19.1%**	**175.3**	**15.3%**
	Dry	**4**	**44.1**	**11.8%**	**0.0**	**0.0%**
	TOTAL	**28**	**374.2**	**100.0%**	**1148.5**	**100.0%**

3.1.2.3 Not included in this report
3.1.3.4 Not included in this report

3.1.3.5 Summer fish measurement information

As part of the summer monitoring program, a subsample of fish are weighed and measured within each sampled habitat unit. Histograms are presented for coho (Figure 3.9) and steelhead (Figure 3.11). Weight-length

relationships are shown for coho (Figures 3.10) and steelhead (Figure 3.12). Future analysis will include fish condition as determined by Fulton's condition factor.

Within the Redwood Creek sample, 241 coho salmon (55% of the total index reach catch) and 146 steelhead trout (99% of the total index reach catch) were weighed and measured. The size range for young of year coho was observed to be 45 to 100 millimeters, while the size range for steelhead trout was 40 to 255 millimeters.

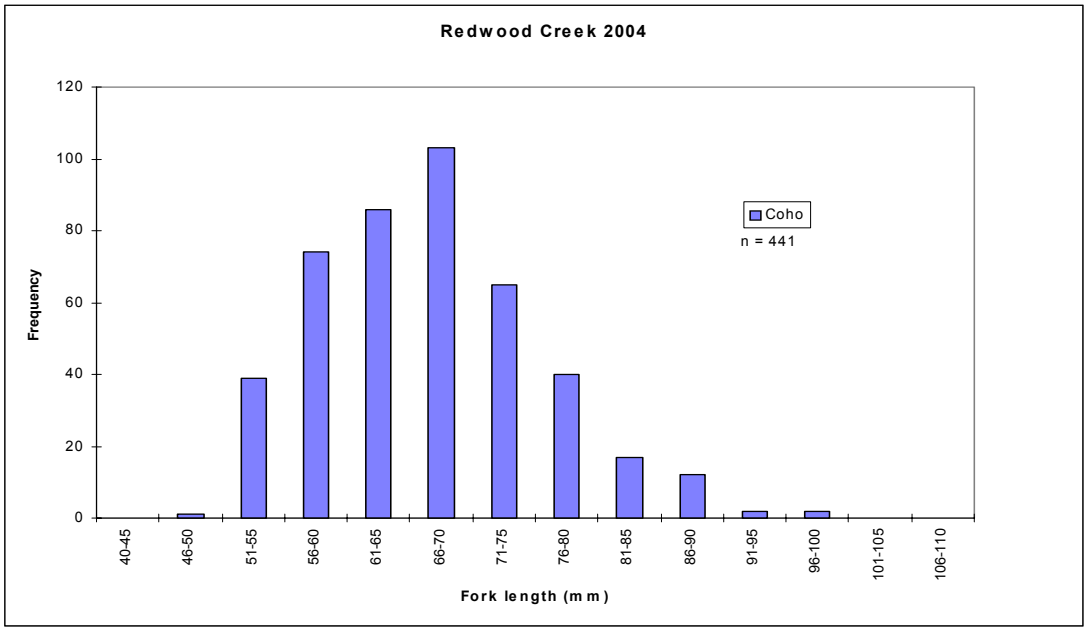

Figure 3.9 Coho histogram for fish measured in the five Redwood Creek index reaches, 2004. Fork length is represented in 5 millimeter bins.

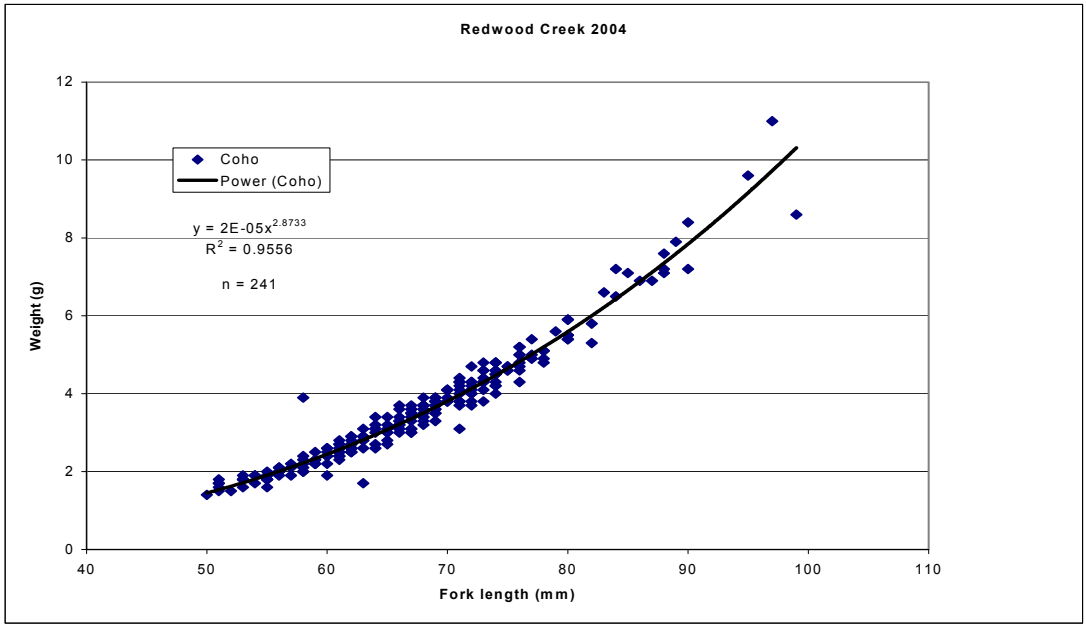

Figure 3.10 Coho weight-length relationships for fish measured in the five Redwood Creek index reaches, 2004.

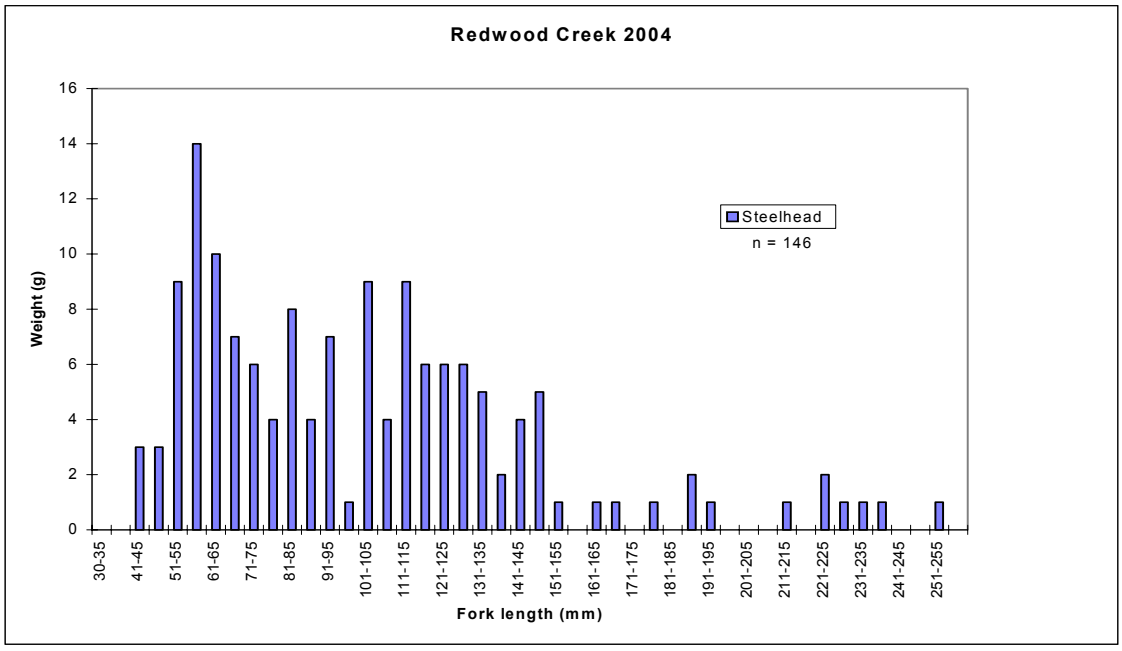

Figure 3.11 Steelhead histogram for fish measured in the five Redwood Creek index reaches, 2004. Fork length is represented in 5 millimeter bins. Multiple peaks represent multiple year classes of O. Mykiss.

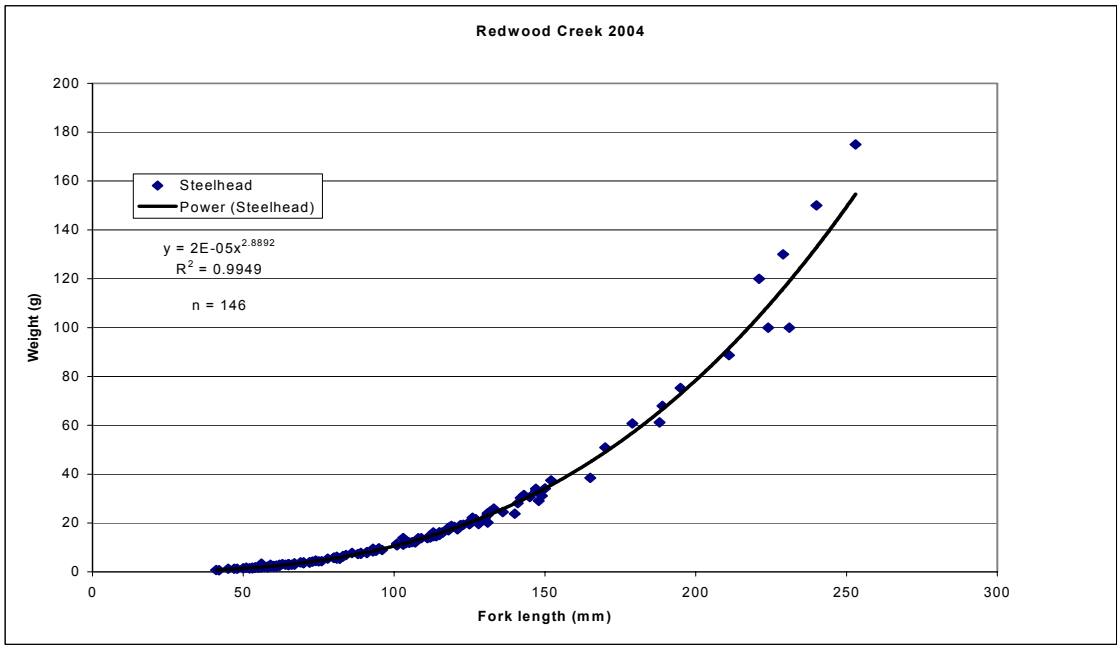

Figure 3.12 Steelhead weight-length relationships for fish measured in the five Redwood Creek index reaches, 2004.

3.2 Coho juvenile population estimate

In summer 2004, through DFG grant monitoring support, the NPS conducted a basinwide snorkel estimate on Redwood Creek for the first time. This increased level of monitoring effort is intended to match the ongoing efforts in Pine Gulch and Olema Creeks, and allow for comparison of the index reach monitoring information collected in the watershed since 1999.

3.2.1 Olema Creek

The summer 2004 habitat survey covered approximately 10.9 kilometers of Olema Creek, beginning at stream km 2.6, downstream of the Olema Ranch Campground and continuing upstream to stream km 13.5, the Randall Ranch House. The snorkel surveys covered 9.8 km of the mainstem starting at stream km 3.7, located at the Vedanta Bridge, and continuing upstream to stream km 13.5, the Randall Ranch House.

Snorkel surveys in the area around the town of Olema was avoided based upon water quality conditions not meeting contact recreational use standards near the time of survey. This water quality monitoring information has been collected as part of the TMDL monitoring process in collaboration with the Regional Water Quality Control Board.

3.2.1.1 Habitat Survey

A total of 798 habitat units were identified (373 pool, 230 flatwater, and 195 riffle units). Overall habitat composition was 47% pool, 29% flatwater, and 24% riffle (Table 3.18). A comparison between visually estimated and measured surface area was conducted for 63 pools to determine a surface area correction factor. The correlation between the estimated surface area and measured surface area was adequate (R^2=0.93). Based on this, a calibration ratio of 1.03 was used to correct the estimated surface area of all units (Figure 3.13).

Table 3.18 Habitat composition of Olema Creek coho survey area, July-August, 2003-2004

Unit type		2003		2004		2005	
		# of units	%	# of units	%	# of units	%
pool		275	51	373	47		
flatwater		69	13	230	29		
riffle		193	36	195	24		
total		537		798			
Survey length		9.2 km		12.4 km			

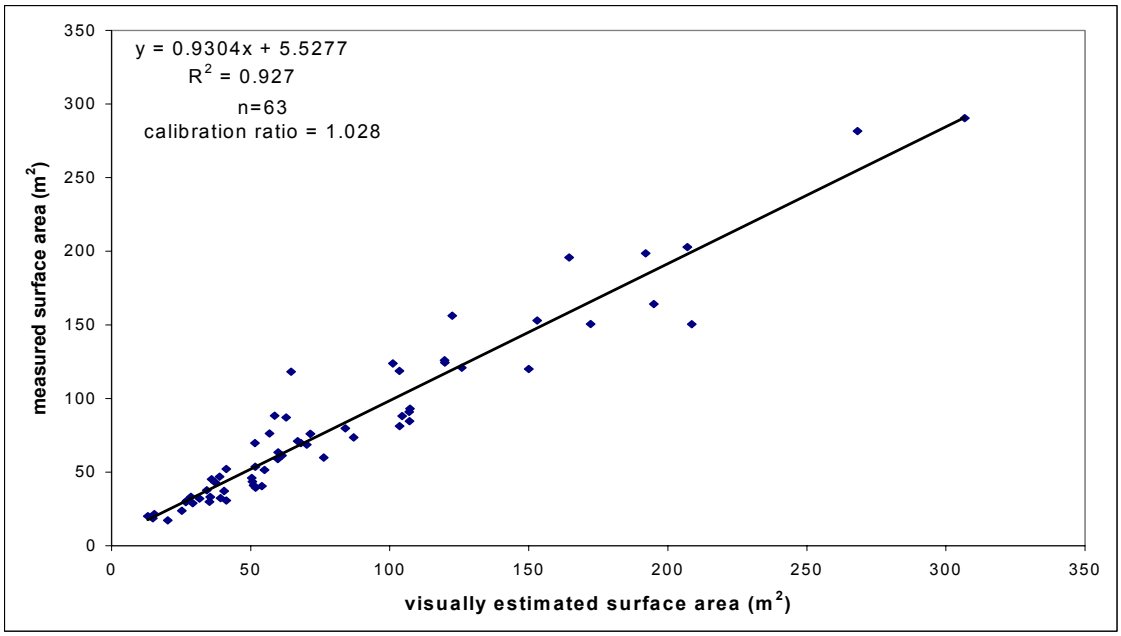

Figure 3.13 Correlation between measured and visually estimated surface area of 63 pools; Olema Creek, July-August 2004

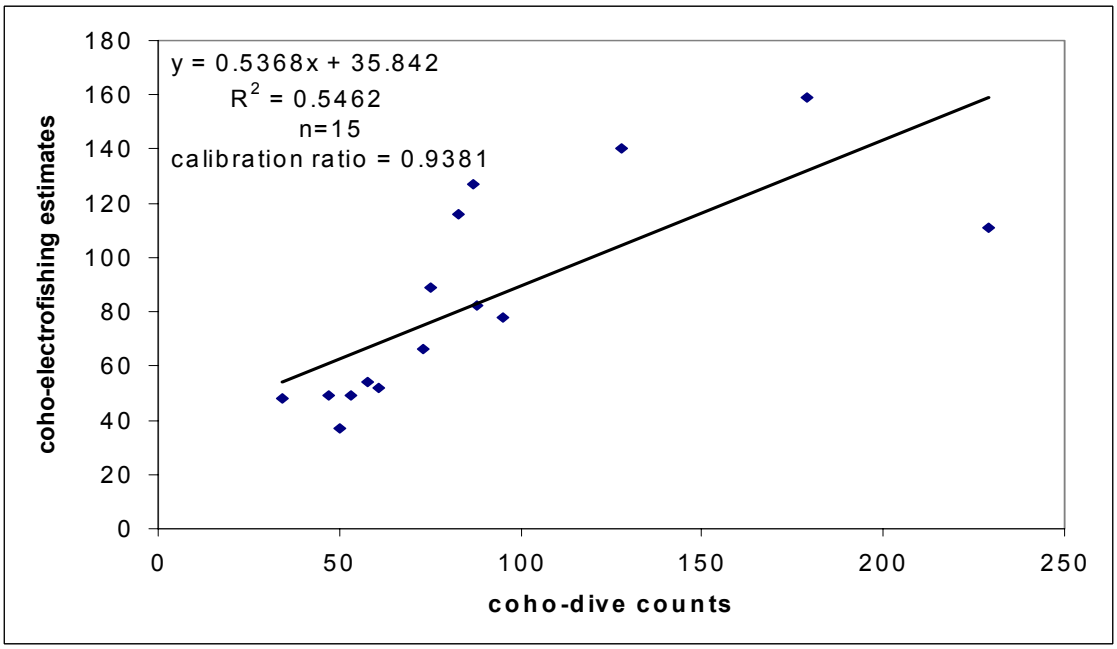

Figure 3.14 Correlation between electrofishing estimates and snorkel counts for 15 pools; Olema Creek, July-August 2004

3.2.1.2 Snorkel counts

We snorkeled 69 of the 373 pools, and counted a total of 5,746 juvenile coho during the summer of 2004. Coho were present in all of the snorkeled pools. Fifteen of the 69 dive pools were electrofished within a day following the

dive counts. *Microfish* population estimates for the electrofished pools were used to calibrate the snorkel counts. Correlation between electrofishing and snorkel counts in 2004 was low (R^2=0.5462) and a calibration ratio of 0.9381 was used to correct the snorkel counts for all pools (Figure 3.14). While this correlation is considered low, it should be noted that the typical number of coho counted per pool was greater than 80. It has been documented that when fish numbers within a snorkel unit exceed 40, counts become more problematic (Hillman et al 1992) snorkel surveys counted in a pool A summary of the snorkel counts is shown in Table 3.19. Coho densities (by both pool length and calibrated surface area), population estimate, and 95% confidence interval were calculated for the coho survey area as a whole (Table 3.20). The total coho salmon population estimate for Olema Creek in 2004 was 29,138 ± 1,591. This is much higher than the first population estimate conducted on Olema Creek in 2003.

Table 3.19 Summary of coho snorkel counts in Olema Creek, July-August 2003-2004

Year	Total stream length surveyed (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2003	9.2	537	275	46	44	2153	1995
2004	12.4	798	373	69	69	5746	5390

Table 3.20 Coho density and population estimates; Olema Creek coho survey area, July-August 2003-2004

Year	Avg. Coho per pool		Density		Population Estimate	Variance	95% confidence Interval
	Raw	Calibrated	coho/m	Coho/m^2			
2003	46.79	43.36	1.934	0.441	11,926	2,057,080	± 3,244
2004	83.28	78.12	3.668	0.835	29,138	550,013	± 1,591

The total coho salmon population estimate for Olema Creek in 2004 is 29,138 ± 1,591. This is a much higher estimate than reported in the first basinwide estimate conducted in 2003 on Olema Creek. This is supported by increased coho densities, which have almost doubled from 2003 to 2004.

3.2.2 Pine Gulch Creek

Summer 2004 represented the fourth year monitoring the natural return of coho salmon to the watershed. Previous years information including smolt trapping and adult surveys have been reported in addition to the basinwide estimates by the NPS (Brown and Ketcham 2002; Ketcham and Brown 2003, Ketcham et al 2004a).

The summer 2004 survey within Pine Gulch Creek covered approximately 8.5 km of the Pine Gulch mainstem starting at stream km 0.3, downstream of index 1b on the Murch farm, and continuing upstream to stream km 9.0, 100 m above index 6 near the Texeira ranch. A 250-meter section between stream km 7.2 and 7.5 was not surveyed because it is deeply incised and heavily overgrown with blackberry and poison oak.

3.2.2.1 Habitat Survey

In 2004, a total of 606 habitat units were identified (293 pool, 116 flatwater, and 197 riffle units). Overall habitat composition (48 % pools, 19% flatwater, and 35% riffle) was similar to that documented in the 2001 - 2003 surveys (Table 3.21). A comparison between visually estimated and measured surface area was conducted for 46 pools to determine a surface area correction factor. The correlation between the estimated surface area and measured surface area was adequate (R^2=0.96). Based on this, a calibration ratio of 0.9805 was used to correct the estimated surface area of all units (Figure 3.15).

Table 3.21 Habitat composition of Pine Gulch coho survey area, 2001-2004

Unit type	2001		2002		2003		2004	
	# of units	%	# of units	%	# of units	%	# of units	%
Pool	248	48	285	45	261	49	293	48
flatwater	83	16	93	15	39	7	116	19
Riffle	189	36	254	40	231	44	197	33
total	520		632		531		606	
Survey length	7.0 km		8.3 km		8.0 km		8.5 km	

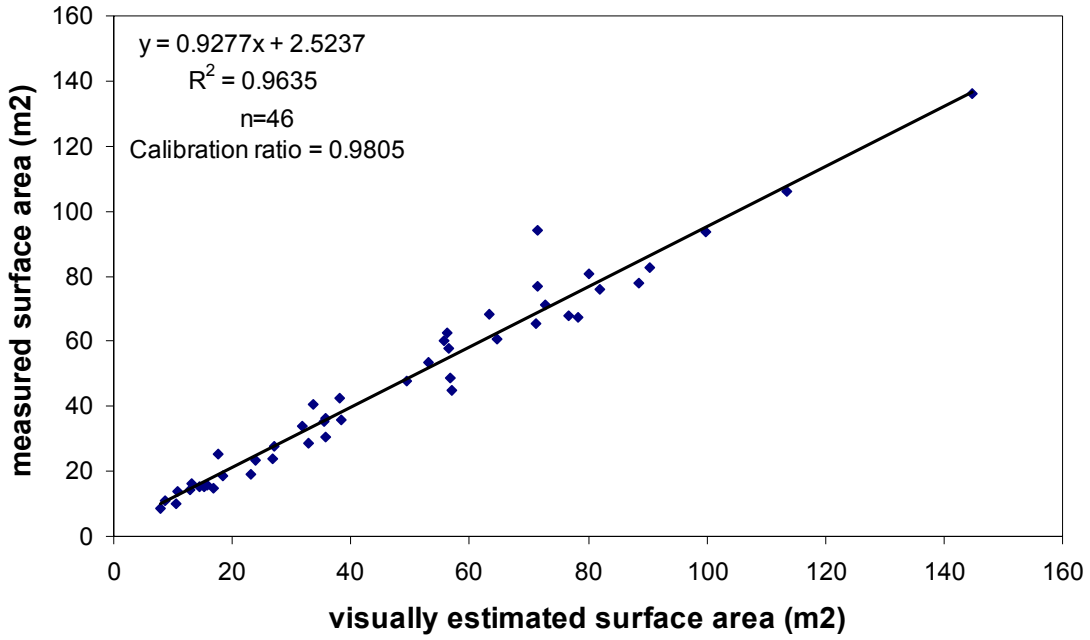

Figure 3.15. Correlation between measured and visually estimated surface area of 46 pools; Pine Gulch Creek, August 2004

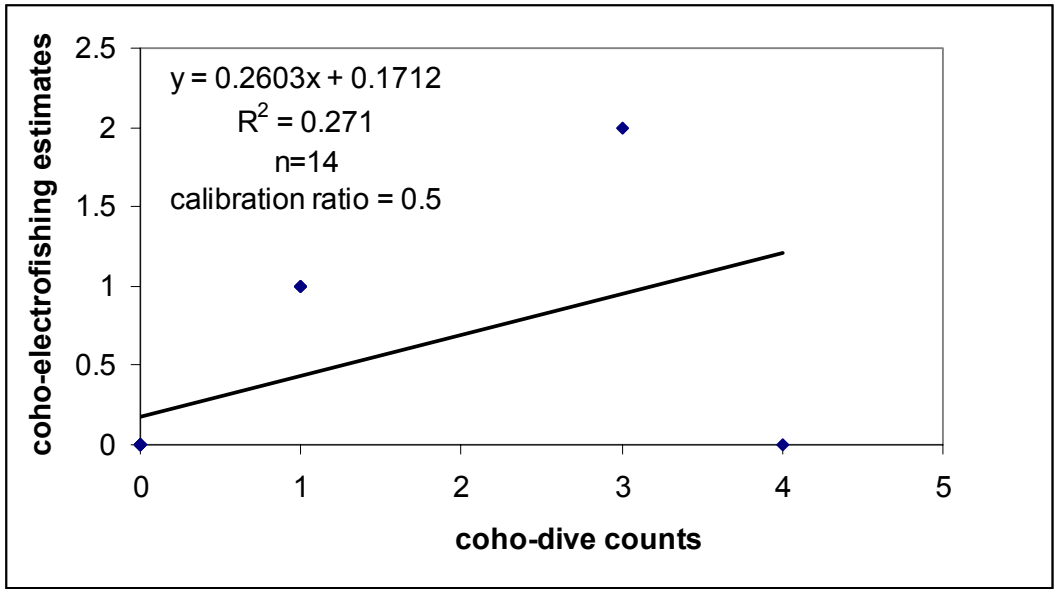

Figure 3.16. Correlation between electrofishing estimates and snorkel counts for 14 pools; Pine Gulch Creek, August 2004

3.2.2.2 Snorkel counts

In 2004, we snorkeled 57 of the 293 pools, and counted a total of 21 coho in 13 of the pools. Fourteen of the 57 dive pools were electrofished within a day following the dive counts. *Microfish* population estimates for the electrofished pools were used to calibrate the snorkel counts using our standard methods. Correlation between electrofishing and snorkel counts was poor (R^2=0.271) and a calibration ratio of 0.5 (Figure 3.16) was identified.

A summary of the snorkel counts is shown in Table 3.22, along with 2001 - 2003 results for comparison. Coho densities (by both pool length and calibrated surface area), population estimate, and 95% confidence interval were calculated for the coho survey area as a whole (Table 3.23). Using our standard methods, the total coho salmon population estimate (using methods described in Dolloff et al 1993) for Pine Gulch Creek in 2004 would be 54 ± 426 with a variance of 38,912.

Based on professional judgement derived from snorkel counts and diver confidence the raw count was utilized for estimating the coho population in Pine Gulch instead of the population estimate developed from snorkel counts calibrated by electrofishing. The estimated coho population for Pine Gulch Creek in 2004 based on the extrapolation of the raw count is 108 fish. Due to the low fish densities we believe that the snorkel observations are a more accurate representation of coho densities then the electrofished estimates, and have chosen not to use the calibration information documented above.

Table 3.22. Summary of coho snorkel counts in Pine Gulch Creek, 2001-2004

Year	Total stream length surveyed (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2001	7.0	520	248	68	28	152	162
2002	8.4	632	285	64	39	239	271
2003	8.0	531	261	49	26	85	110
2004	8.7	606	293	57	13	21	11*

Table 3.23. Coho density and population estimates; Pine Gulch Creek coho survey area, September 2001 - 2004

Year	Avg. Coho per pool		Calibrated Density		Population Estimate	Variance	95% confidence Interval
	Raw	Calibrated	coho/m	coho/m^2			
2001	2.24	2.38	.1475	.0452	589	24104	± 329
2002	3.73	4.23	.2634	.0786	1205	25232	± 337
2003	1.73	2.24	.1407	.0411	585	11772	± 236
2004	0.37	0.19*	.0133*	.0039*	108		

* Not used for population estimate or reporting due to low confidence in electrofishing efficiency.

Using the same raw numbers for density calculations, density estimates for coho on Pine Gulch Creek in 2004 are 0.0265 fish/meter and 0.0077 fish/meter^2. Although there are no confidence intervals for this estimate we believe the population estimate extrapolated from the raw dive numbers to be more accurate estimate of coho populations in the watershed. The high variance between snorkel and electrofishing may be attributed to the very low numbers of coho per pool (0 to 4 individuals). When sampling populations of juvenile salmonids with densities less than 0.5 fish/meter^2, snorkel counts in complex pools are considered a more accurate approach at estimating the true population than electrofishing (Roni and Fayram 2000). The maximum coho density observed in any pool sampled by snorkel crews in 2004 on Pine Gulch Creek was 0.117 fish/meter^2. Nonetheless, this is still the lowest estimate in the four years of juvenile coho monitoring in Pine Gulch Creek.

3.2.3 Redwood Creek

In summer 2004, we added Redwood Creek to our basinwide summer snorkel estimate program. Habitat surveys were conducted on 7.4 kilometers of the watershed beginning 100 meters downstream of the Pacific Way Bridge and ending upstream at the waterfall at stream kilometer 7.4. Habitat surveys were also performed from the confluence with the Pacific Ocean to 100 meters below the Pacific Way Bridge. This section is not reported because it was determined to be part of the Redwood Creek estuary and therefore not representative of the mainstem Redwood Creek habitat. The snorkel surveys covered the entire 7.4 kilometers previously surveyed during the habitat surveys.

3.2.3.1 Habitat Survey

A total of 477 habitat units were identified (179 pool, 166 flatwater and 132 riffle) during the 2004 surveys. Overall habitat composition was 37% pool, 35% flatwater, and 28% riffle (Table 3.24). The major distinction between pool and flatwater is the maximum depth of 0.3 meters. The low flow conditions observed in 2004 likely resulted in a higher flatwater count than typical in our watersheds. A comparison between the visually estimated and measured surface area was conducted on all 179 pools. All pools were measured in order to compare surface area calculations with pool habitat calculations to be collected in 2005 summer habitat surveys. The correlation between the estimated surface area and measured surface area was good (r^2=0.96). Based on this, a calibration ratio of 1.005 was used to correct the estimated surface area of all units (Figure 3.18).

Table 3.24 Habitat composition of Redwood Creek coho survey area, July-August, 2004

Unit type		2004		2005	
		# of units	%	# of units	%
Pool		179	37		
Flatwater		166	35		
Riffle		132	28		
total		477			
Survey length			7.4 km		

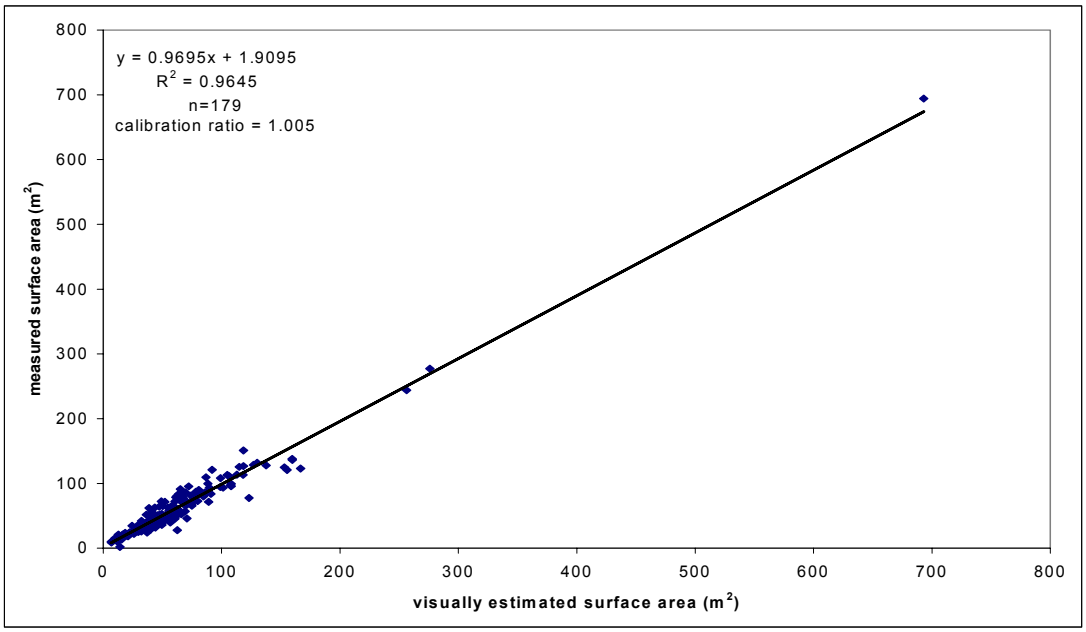

Figure 3.18 Correlation between measured and visually estimated surface area of 179 pools; Redwood Creek, July-August 2004

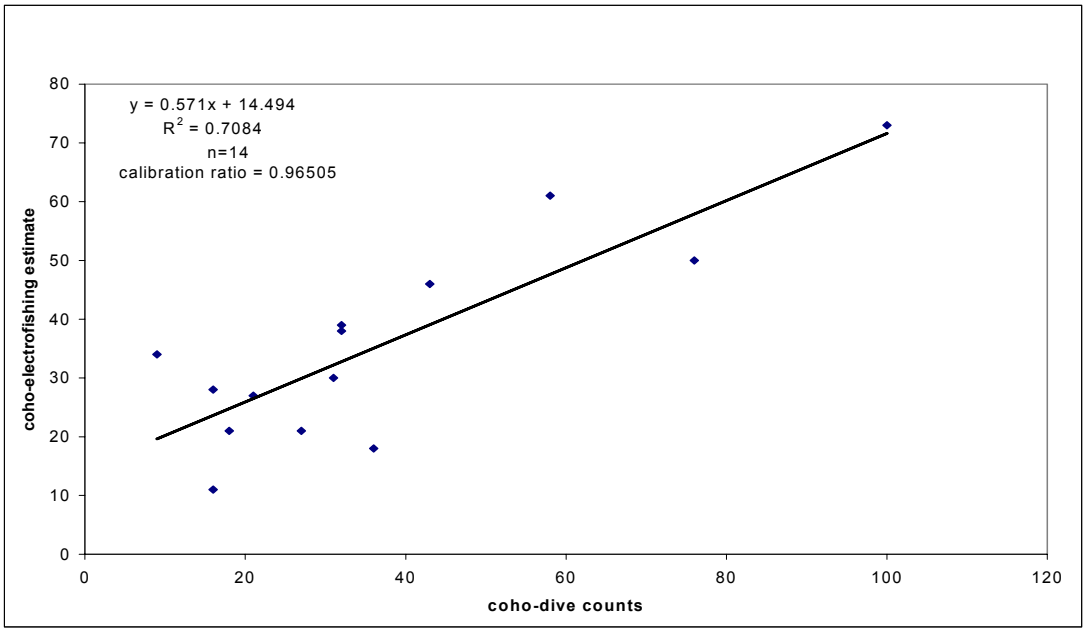

Figure 3.19 Correlation between electrofishing estimates and snorkel counts for 14 pools; Redwood Creek, July-August 2004

3.2.3.2 Snorkel counts

We snorkeled 57 of the 179 pools, and counted a total of 2,168 juvenile coho during the summer of 2004. Coho were present in all of the snorkeled pools. Fourteen of the 57 dive pools were electrofished within a day following the dive counts. *Microfish* population estimates for the electrofished pools were used to calibrate the snorkel counts. Correlation between electrofishing and snorkel counts in 2004 was low (R^2=0.7084) and a calibration ratio of 0.96505 was used to correct the snorkel counts for all pools (Figure 3.12). A summary of the snorkel counts is shown in Table 3.19. Coho densities (by both pool length and calibrated surface area), population estimate, and 95% confidence interval were calculated for the coho survey area as a whole (Table 3.20). The total coho salmon population estimate for Redwood Creek in 2004 was 7,121 ± 1,615. While the estimate is far lower, the densities observed in Redwood Creek during summer 2004 are approximately 50% of those observed in Olema Creek.

Table 3.25 Summary of coho snorkel counts in Redwood Creek, July-August 2004

Year	Total stream length surveyed (km)	Total number of habitat units	Number of Pools			Coho Counted	
			Total	Snorkeled	w/ Coho	Raw	Calibrated
2004	7.2	477	179	57	57	2,168	2,092

Table 3.26 Coho density and population estimates; Redwood Creek coho survey area, July-August 2004

Year	Avg. Coho per pool		Density		Population Estimate	Variance	95% confidence Interval
	Raw	Calibrated	coho/m	Coho/m²			
2004	38.03	36.71	2.26	0.612	7,121	559,124	± 1,615

4.0 CONCLUSIONS

The data analysis included in this progress report represents the bulk of summer monitoring efforts conducted under the CDFG monitoring grant. Much of the information presented in this interim report will be incorporated into comprehensive watershed reports to be completed in spring 2006. The comprehensive reports will allow for analysis of monitoring results between different life stages, as well as incorporation of data collected on the tributary sites including John West Fork, Quarry Gulch, and Cheda Creek.

Through this progress report, we plan to continue refinement of both our field methods and analytical procedures to allow for stronger interpretation of fisheries data collected through this program. In addition, we will evaluate these statistics to determine whether field monitoring effort may be reduced, or is in need of expansion.

4.1 Olema Creek

The results reported for Olema Creek include a summer juvenile coho population estimate of 29,138 ± 1,591 for the mainstem section extending from the Olema Ranch Campground to stream km 15.0. This represents a large portion of the perennial mainstem habitat. Through our index reach monitoring program, the NPS observed coho densities of 4.26 ±0.71 coho per meter and 0.89 ±0.15 coho per square meter for pools. Watershed survey wide observed coho densities were 3.84 ±0.62 coho per meter and 0.79 ±0.13 coho per square meter for all of the habitat units surveyed as part of the index reach monitoring program. These densities far exceed densities of coho observed in 2001 when pool densities were reported at 2.49±0.22 coho per meter and 0.62 ±0.05 coho per square meter, and 1.67±0.16 coho per meter and 0.44±0.04 coho per square meter overall. We also see that summer 2004 coho densities in flatwater habitat units are more than twice that observed in 2001.

Our steelhead density observations watershed wide include 1.70 ±0.32 steelhead/m and 0.35 ±0.07 steelhead per square meter overall showed densities Steelhead densities were higher in sampled flatwater units than in pool habitat units.

The fish density information collected for Olema Creek is higher than the density information presented in the NOAA Fisheries 2001 coho status report and any previously reported coho densities in Olema Creek (Figure 4.1). Total catch in Olema Creek for 2004 (1,406 coho) was higher than the total catch for the same index reaches sampled in 2001 (950 coho) indicating progress in the recovery of this year class.

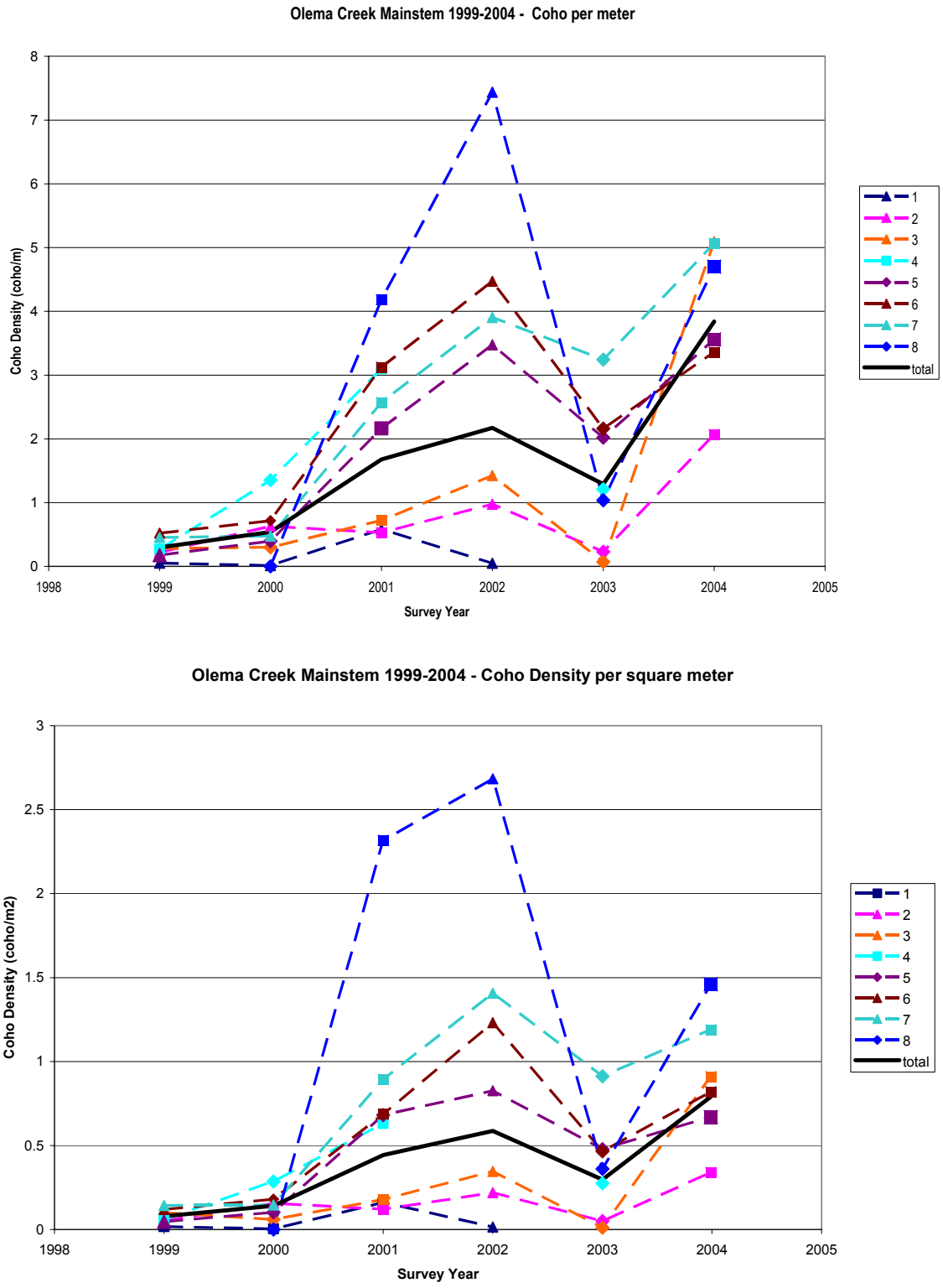

Figure 4.1 Juvenile coho salmon density per meter observed in eight index reach locations within the mainstem of Olema Creek Marin County, CA, 1999-2004 (NPS data). Point shape represents year class. Top: fish/m; Bottom: fish/m^2.

4.2 Pine Gulch Creek

The results observed in Pine Gulch Creek documented only 5 coho during electrofishing and 21 coho juveniles during snorkel surveys, with an estimated juvenile population of only 108 fish. When compared to the 2001 survey, where the basinwide population estimate was 589 ± 329, we are very discouraged with the reduced densities for this year class.

This is extremely low and was unexpected given the results of the preceeding three years. The presence of coho and distribution in the lower four kilometers of the watershed indicate that it is likely the result of very sparse spawning. NPS staff conducted extensive surveys (7 total) throughout the preceeding spawning season (2003-04), and documented only one coho redd. No coho were actually observed during the spawning surveys. Adult spawners are typically harder to detect in the watershed, but in all previous years, and the spawning season since, we had detected coho individuals within the watershed. A total of 12 steelhead redds and one steelhead adult were observed during these surveys.

While coho densities were negligible, we documented watershed steelhead densities averaged between the index reaches of 1.56 ±0.25 steelhead YOY/meter, and 0.50 ±0.08 steelhead YOY/square meter. These densities are comparable to those documented for steelhead within the Olema watershed (above) indicating summer rearing conditions not likely the cause of low coho numbers.

The low coho numbers observed in Pine Gulch Creek are not indicative of other watersheds in the region, where some of the highest observed juvenile densities have been documented. We observed a total of 249 coho smolts leaving the watershed in spring of 2002, which assuming a 10% ocean survival would have yielded 20-30 coho adults returning. Based on the winter 2003-04 spawner result of one coho redd and no observed adults, it is likely that the cause of this low summer count occurred during the ocean phase of the coho lifecycle.

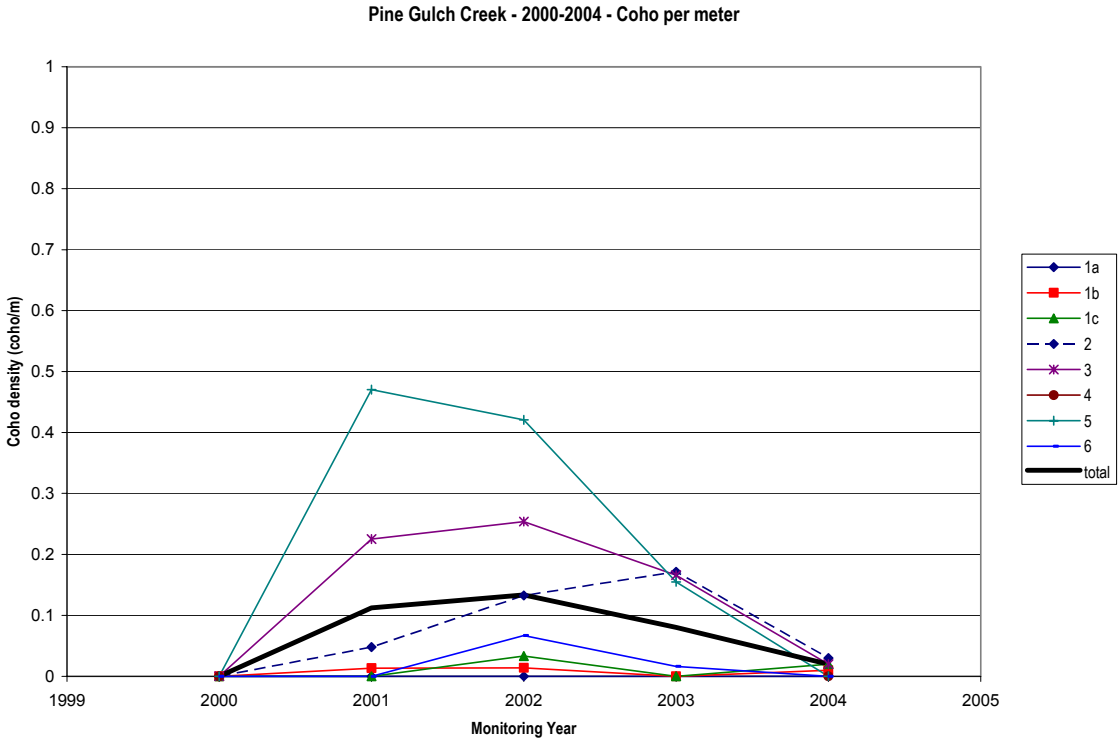

Figure 4.2 Juvenile coho salmon density per meter observed in seven index reach locations within the mainstem of Pine Gulch Creek, Marin County, CA, 2000-2004 (NPS data).

4.3 Redwood Creek

The results reported for Redwood Creek include a summer juvenile coho population estimate of 7,121 ± 1,615 for the mainstem section extending from the Pacific Way Bridge to stream km 7.4. Long-term monitoring in Redwood Creek, Marin County has shown a range in coho per meter from 0.03 to 1.51 in index reach sites monitored between 1988 and 2001 in Redwood Creek (Smith 2001). Although densities for index reach sites have not been calculated yet, densities observed in basinwide snorkeling (2.26 fish/meter) indicates densities much higher than reported in previous years (Figure 4.3).

A comprehensive watershed monitoring report to be completed in 2006 will include more detailed information on data collected during the 2004 juvenile coho summer monitoring project. This report will include a comparison of results from previous years as well as relating juvenile populations to adult escapement.

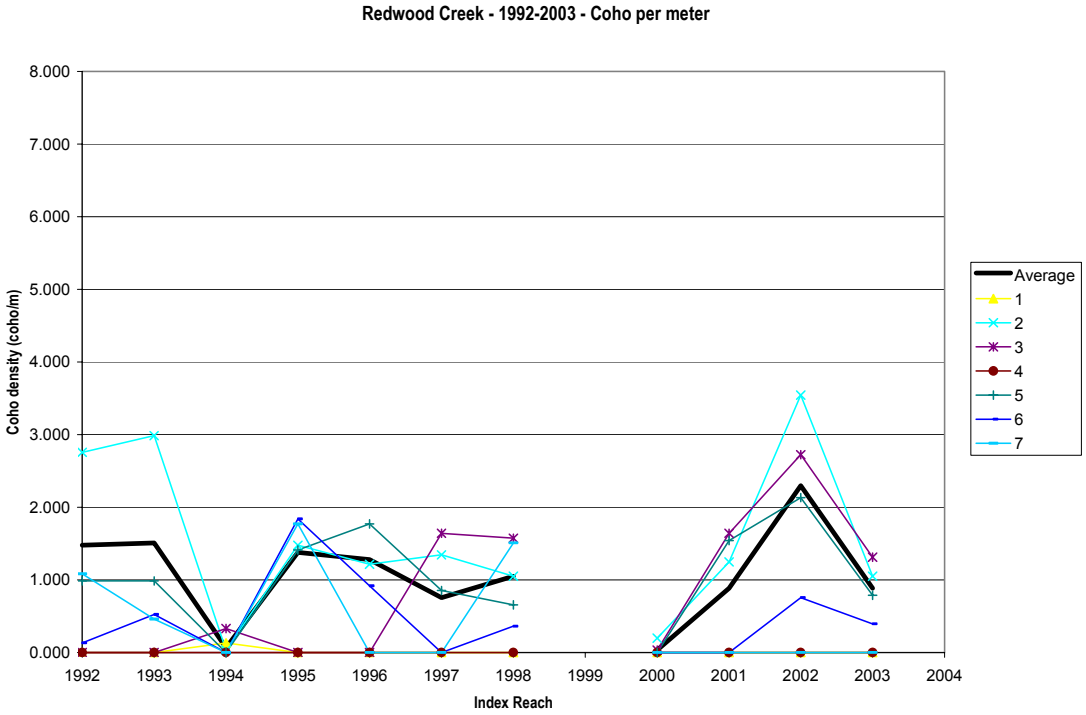

Figure 4.3 Juvenile coho salmon density per meter observed in seven index reach locations within the mainstem of Redwood Creek Marin County, CA, 1992-2003 (J. Smith-SJSU data).

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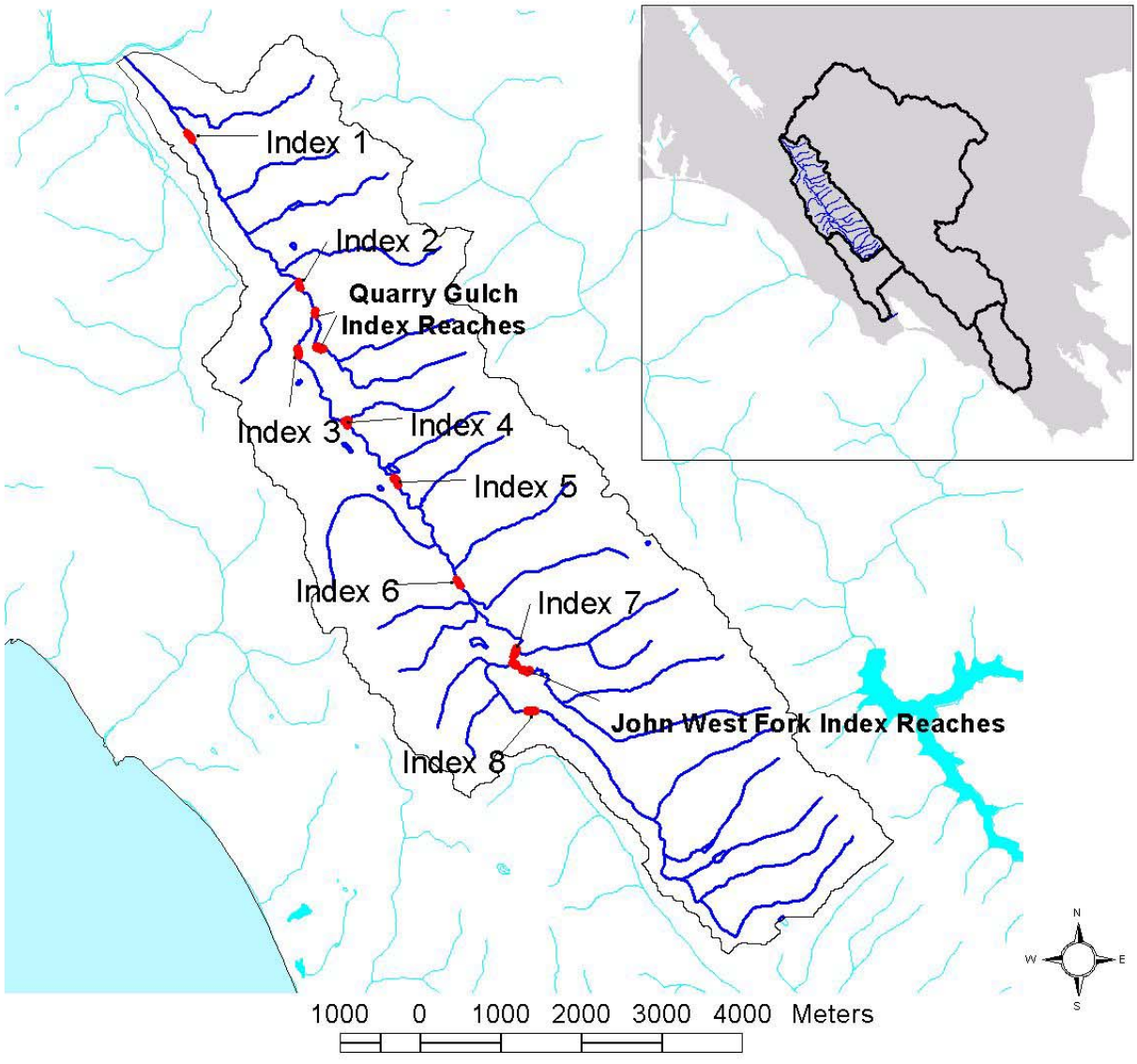
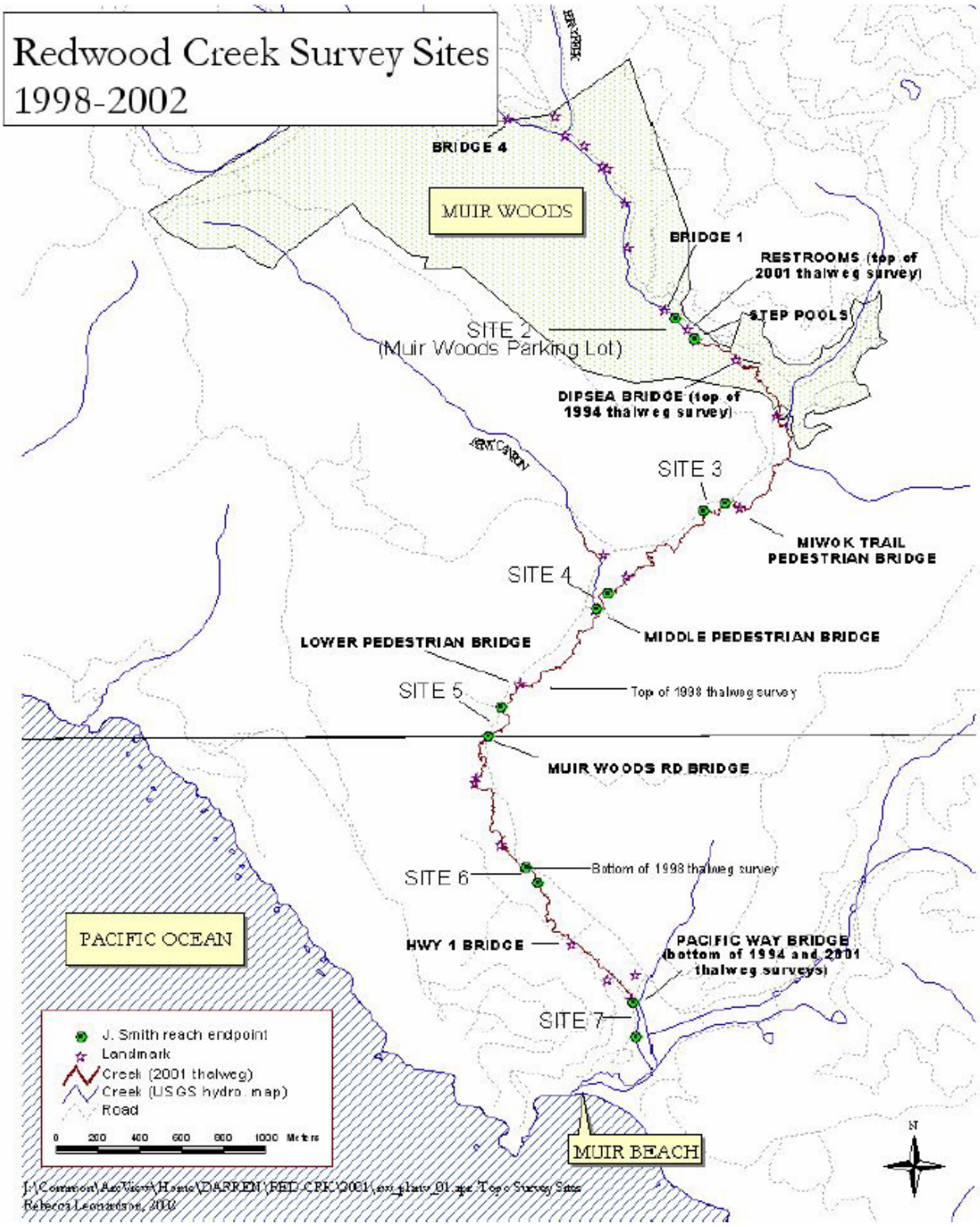
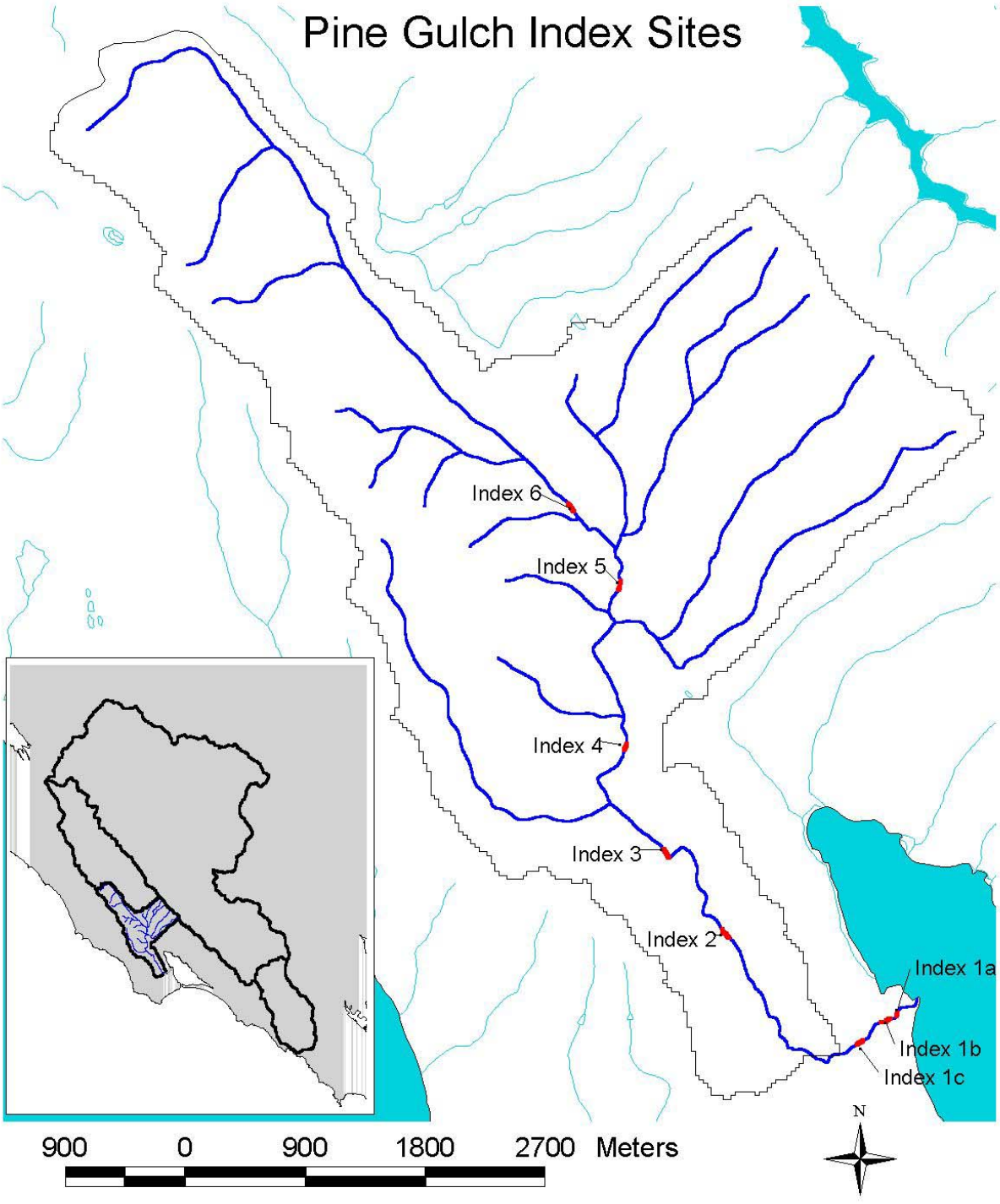
APPENDIX A

WATERSHED INDEX REACH MAPS

Olema Creek Index Reaches




Redwood Creek Survey Sites
1998-2002
BRIDGE 4
MUIR WOODS
BRIDGE 1
RESTROOMS (top of 2001 thalweg survey)
STEP POOLS
SITE 2
(Muir Woods Parking Lot)
DIPSEA BRIDGE (top of 1994 thalweg survey)
SITE 3
MIWOK TRAIL PEDESTRIAN BRIDGE
SITE 4
MIDDLE PEDESTRIAN BRIDGE
LOWER PEDESTRIAN BRIDGE
SITE 5
Top of 1998 thalweg survey
MUIR WOODS RD BRIDGE
SITE 6
Bottom of 1998 thalweg survey
PACIFIC OCEAN
HWY 1 BRIDGE
PACIFIC WAY BRIDGE (bottom of 1994 and 2001 thalweg surveys)
SITE 7
J. Smith reach endpoint
Landmark
Creek (2001 thalweg)
Creek (USGS hydro. map)
Road
0 200 400 600 800 1000 Meters
MUIR BEACH
N
J:\Common\ArcView\Home\DARREN\RED_CRK\2001\ovr_plate_01.apr Topo Survey Sites
Rebecca Leonardson, 2010


Pine Gulch Index Sites
Index 6
Index 5
Index 4
Index 3
Index 2
Index 1a
Index 1b
Index 1c
900 0 900 1800 2700 Meters
N